THE UNIVERSITY OF ALBERTA

THE PETROLOGY OF THE THEKULTHILI LAKE AREA, NORTHWEST TERRITORIES

by

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A THESIS

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DEDICATION

This thesis is dedicated to Dr. J.F. Henderson, who originally interpreted the time-stratigraphic position of the Nonacho Series.

ABSTRACT

Henderson (1939) originally mapped alternating intrusive nonconformable field relations between a gneissic basement and the Nonacho Series sedimentary strata: away from the contact, the gneisses were indistinguishable. Burwash and Baadsgaard (1962) applied K/Ar isotopic age determination methods to resolve the age of the Nonacho and concluded that differential reactivation of the basement complex during Hudsonian time had metamorphosed parts of the Nonacho Series, and had caused the field relations described by Henderson. This interpretation placed Nonacho deposition in pre-Hudsonian time. McGlynn (1965) used field relations to conclude that the Nonacho was post-Hudsonian in age.

This study has used petrologic data and field relations to assign a time-stratigraphic position to the Nonacho Series. Two hundred and thirty two thin sections were examined from rock suites collected in the field seasons of 1958 (Burwash and Taylor) and 1975 (Burwash and Donaghy). The samples gave petrologic data along the periphery of the Nonacho for about 45 miles of length. Seven profiles, from one to four miles in length which cross the strike of the rocks in the area, were traversed and are included in this suite.

Hornfelsic and lower greenschist metamorphic mineral assemblages were found in the peripheral Nonacho strata. An intrusive granite and mantled gneissic dome were also

noted in the thesis area, indicative of reactivation within the basement complex.

Geologic and petrologic data, isotopic age dates, and aeromagnetic observations were synthesized to produce a geologic sequence of events.

The Nonacho Series consists of sedimentary strata of intra-orogenic Hudsonian age, which were possibly deposited at the same time as the Thluicho Lake Group in northern Saskatchewan. Late Hudsonian regional reactivation of the basement complex is represented by an intrusive granite west of the Nonacho, and remobilized gneisses or altered gneisses south and east of Thekulthili Lake. The later reactivation has obscured the basement-Nonacho field relations: there are now both nonconformable early Hudsonian and intrusive or metamorphic late Hudsonian contacts with the Nonacho Series.

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CHAPTER ONE

INTRODUCTION

1.1 General Statement

J.F. Henderson of the Geological Survey of Canada (1937) mapped a Proterozoic sequence of sedimentary rocks in the Thekulthili Lake area, Northwest Territories, naming this sequence the Nonacho Series. Later, Burwash and Baadsgaard (1962) conducted studies of the field relations and isotopic age of the Nonacho Series and placed it in the Lower Proterozoic. McGlynn (1969), on the basis of sedimentary chacteristics, assigned the Nonacho Series to the Paleohelikian period. To date, the actual time-stratigraphic position of the Nonacho is uncertain.

Henderson (1937) used time-stratigraphic units established by Stockwell (1932) in the Great Slave Lake area, and Alcock (1936) in the Lake Athabasca area, to assign the Nonacho Series an age and stratigraphic position (Figure 1). The folded and faulted nature of these strata, which lie non-conformably on a granitic crystalline basement complex, caused Henderson to place the Nonacho in the Proterozoic (1948).

One anomalous feature is apparent on Henderson's Nonacho Lake map sheet: (Henderson, 1939, GSC Map 526A) along the east shore of Thekulthili Lake is a contact between the Nonacho Series and its neighbouring rocks showing an alternating non-

conformable and intrusive relationship. Only at the contact with the Nonacho could the "younger" granite be distinguished from the "older" granite; the two being essentially identical in most respects.

These field relations prompted Burwash, with the assistance of R.S. Taylor, to visit the area in 1958, and examine the contacts. On the basis of field relations alone, Burwash was not able to unequivocally resolve the stratigraphic relationships of these three rock units. Later, K-Ar isotopic ages obtained by Baadsgaard indicated the presence of both older and younger granites.

Burwash and Baadsgaard synthesized their studies of the Thekulthili Lake area in 1962. The Nonacho Series was placed in the Lower Proterozoic, being post-Kenoran and pre-Hudsonian in age.

McGlynn (1969, p. 94) concluded after several years of study that the Nonacho Series was deposited after the main regional metamorphic episode of the Hudsonian orogeny, and reflects infilling of faulted valley depressions. This places the Nonacho in the Paleohelikian rather than the Aphebian. (Lower Proterozoic).

The object of this thesis is to present data which support a new approach towards interpreting the age of the Nonacho Series.

FIGURE 1

Lithostratigraphic Correlation in the
Western Canadian Shield
(After Henderson, 1937)

<table>
<tr><th>Great Slave Lake Area
(Stockwell, 1932)</th><th>Athabaska Lake Area
(Alcock, 1936)</th><th>Nonacho Lake Area
(Henderson, 1937)</th></tr>
<tr><td>Basic intrusives
sills and dykes of diabase</td><td rowspan="2"></td><td>Basic intrusives
Diabase dykes</td></tr>
<tr><td>Intrusive contact</td><td>Intrusive contact</td></tr>
<tr><td>Et-Then series
Conglomerate, sandstone, quartzite</td><td>Athabaska series
Basalt flows, conglomerate, arkose, sandstone, shale</td><td></td></tr>
<tr><td colspan="3">Unconformity</td></tr>
<tr><td rowspan="3">Dioritic intrusives
Diorite, quartz-diorite, syenite, quartz-syenite</td><td>Granite</td><td>Granite, granodiorite, etc.</td></tr>
<tr><td>Intrusive contact</td><td></td></tr>
<tr><td>Gabbro, norite, peridotite</td><td></td></tr>
<tr><td colspan="3">Intrusive Contact</td></tr>
<tr><td>Great Slave group
conglomerate, arkose sandstone, quartzite, shale, slate, iron formation, dolomite, limestone, breccia, basalt, andesite, trachyte, rhyolite</td><td>Beaverlodge series
Quartzite, conglomerate, iron formation</td><td>Nonacho series
Conglomerate, shale, arkose, quartzite</td></tr>
<tr><td colspan="3">Unconformity</td></tr>
<tr><td>Granitic intrusives
Granite, granodiorite, quartz-diorite, chloritized granite</td><td>Granitic intrusives
Granite, granodiorite, quartz-syenite, pegmatite</td><td>Granitic intrusives
Granite, granodiorite, etc.</td></tr>
<tr><td colspan="3">Intrusive contact</td></tr>
<tr><td>Wilson Island group
Conglomerate, arkose, quartzite, phyllite, dolomite, iron formaation, schist, basalt, andesite, trachyte, rhyolite</td><td>Tazin group
Limestone, dolomite, quartzite, argillite, conglomerate, mica schist, gneiss, volcanic glows and fragmental rocks</td><td></td></tr>
</table>

1.2 Previous Work

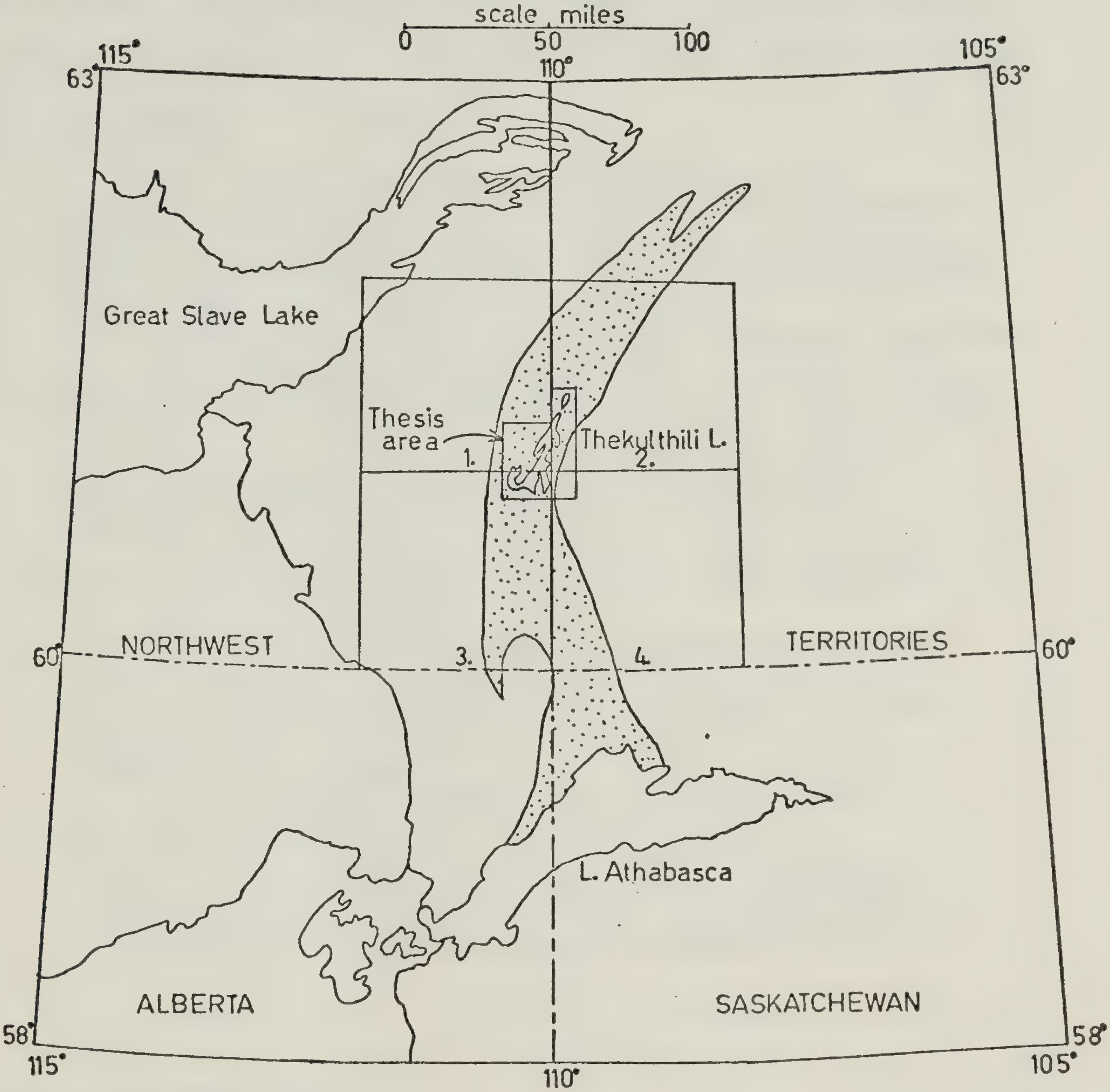
With the exception of Camsell's expedition up the Tazin and Taltson Rivers (Geological Survey of Canada, Memoir 84, 1916), Henderson (1937) conducted the first geological studies in the area. The Nonacho Series was first encountered and named by him in the Nonacho Lake and Taltson Lake map areas. Geological Survey of Canada Preliminary Report 37-2 details his field observations and stratigraphic succession of the area.

Wilson (1941) mapped the Fort Smith map area south of the Taltson Lake area. The extreme northeast corner of this map covers the south end of Thekulthili Lake. Here, Wilson used the same map units as Henderson in describing the Nonacho Series to give unity to the two map areas. He referred to the gneisses south of Thekulthili Lake as "Tazin Equivalent", relating them to the geology of the Lake Athabasca, Saskatchewan area. Mulligan and Taylor (1969) completed the Hill Island Lake map area in 1954. The extreme northwest corner of their map area was near the southeastern corner of Thekulthili Lake and completed the geology of the thesis area.

Figure 2 shows the four map areas which cover the Thekulthili Lake area. The coordinate 61°N/110°W is the point common to all four map areas and lies immediately south and east of Thekulthili Lake. This early work was dominated primarily by Henderson's conclusions from the Taltson-Nonacho Lake areas.

FIGURE 2.

GENERAL LOCATION MAP



MAP AREAS :
1. Taltson Lake (Henderson, 1937)
2. Nonacho Lake (Henderson, 1937)
3. Fort Smith (Wilson, 1941)
4. Hill Island Lake (Mulligan & Taylor, 1969)

▨ P€ Metasedimentary rocks

(after Watanabe, 1962)

Wilson (1941) and Mulligan and Taylor (1969) extended Henderson's map units southward into their map areas.

In his Preliminary Report of 1937, Henderson described his first encounters with the intrusive non-conformable alternating nature in the granitic rocks adjacent to the Nonacho Series. He stated:

> The "older" granitic intrusives can be differentiated with certainty from the "younger" granitic intrusives only along and near contacts with the Nonacho sediments where the unconformable relations can actually be observed.[1]
>
> The intrusive relations of the "younger" granite to the sediments is quite evident. Near the contact the arkose and quartzite are baked to a pink, glassy quartzose rock, the slates and greywackes are altered to phyllites and micaceous schists, and both types of sediments are cut by many granite and pegmatite dykes.
>
> The unconformable relations between the sediments and the "older" granite are well exposed at several localities ....
>
> Along the contact there is a breccia conglomerate formed of angular blocks of granite up to 2 feet in diameter in an arkosic matrix ... the change from the breccia conglomerate to the quartzite is sharp.[2]
>
> As previously stated, no method is known of distinguishing the "younger" granitic intrusives from the "older", away from the actual contact with the sediments. Therefore, the description of the "older" granites applies equally well to the "younger" granites.[3]

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[1] Henderson, J.F., 1937: Nonacho Lake Area, Northwest Territories, Preliminary Rept.; Geol. Surv. Can., Paper 37-2, p. 4.

[2] ibid., p. 14-15.

[3] ibid., p. 18.

The anomalous nature of the sedimentary rock to granitic rock contact, expressed clearly by Henderson, was on the basis of this "younger"-"older" granite interpretation upon which his stratigraphic succession was based.

Burwash visited Thekulthili Lake in 1958 in an attempt to resolve the enigmatic east-shore contact. He observed chloritic basement gneisses non-conformable to boulder conglomerates of the basal Nonacho Series, as well as apparent lithologic gradations from granite gneisses into arkosic sandstones. The prime objective of this trip to was obtain rocks from above and below the contact for purposes of K-Ar dating.

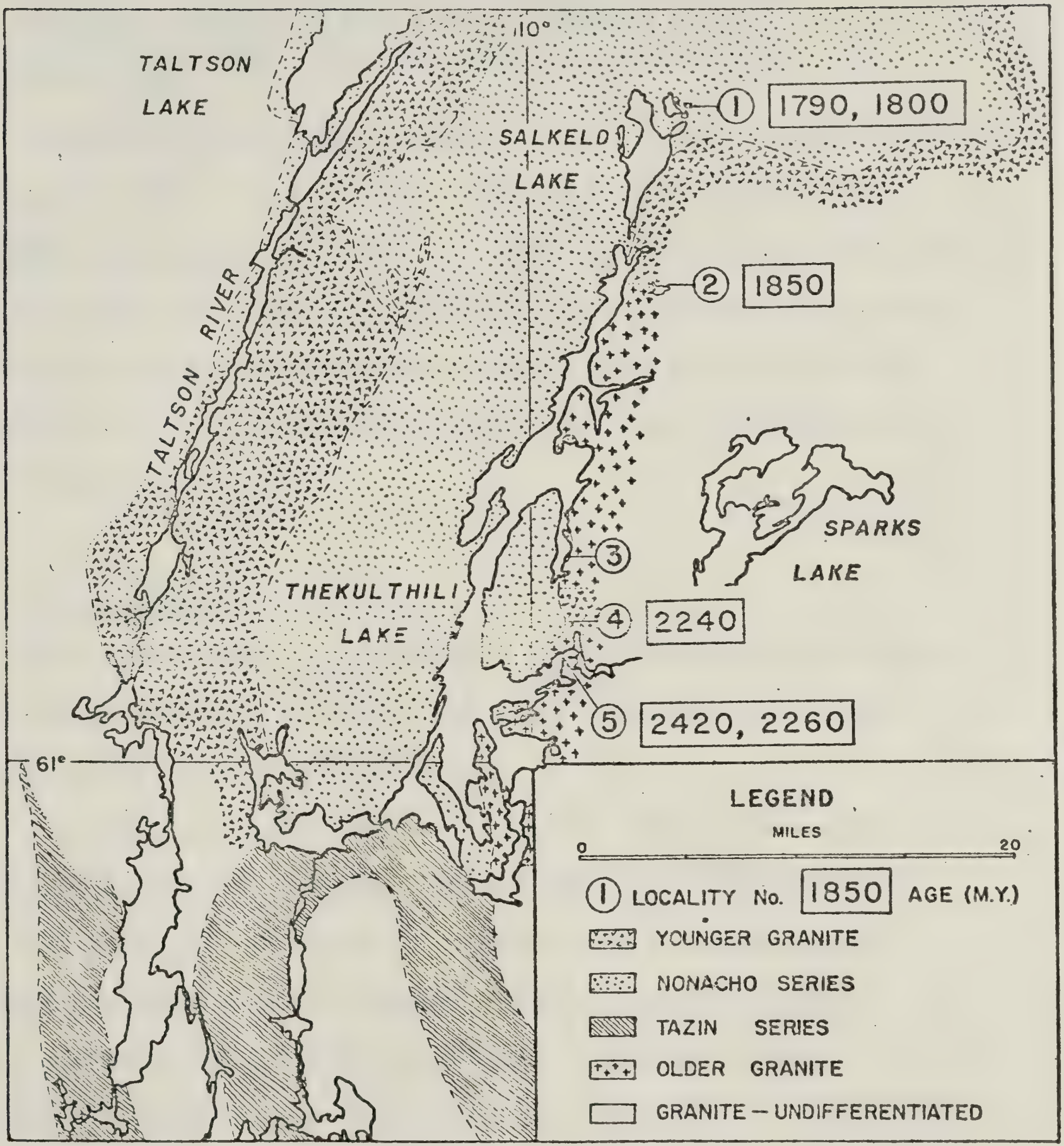
The altered nature of the contact zone hampered this exercise: nevertheless six dates were obtained (Burwash and Baadsgaard, 1962). The results showed "survival values" of 2240 and 2420 million years to the southeast (see Figure 3). Burwash interpreted these results to be differential regional metamorphic effects on a pre-Hudsonian (Archean) basement complex. This would have been accompanied by folding and faulting of the Nonacho Series.

More recent work by McGlynn provided another interpretation. McGlynn mapped the Nonacho Series and adjacent rocks between the years 1966 and 1970. He stated (1970) that, "All Nonacho strata are essentially unmetamorphosed".

A study of the adjacent granitic rocks led McGlynn to the following conclusions:

Location Map of Isotope Age Dates

FIGURE 3



(after Burwash and Baadsgaard, 1962)

> Evidence from contact areas on both sides of the basin indicate that all plutonic rocks in the contact with Nonacho strata are older and therefore part of the basement in which the sediments were deposited. Commonly along the western margin on the basin evidence of unconformity has been destroyed or obscured by faulting.[1]

McGlynn placed the Nonacho Series in the Paleohelikian. He stated (1969, p. 94) that, "Nonacho rocks rest on a basement of granitic gneiss ... they are not cut by younger granites and are unmetamorphosed". His time-stratigraphic position of the Nonacho Series correlated with the Martin Formation in the Athabasca-Beaverlodge area, Saskatchewan area (Figure 4).

1.3 Physiography

The study area is located in the Northwest Territories bounded by latitudes 60°53' and 61°27' North, and longitudes 109°45' and 110°25' West.

The physiographic features typify most of the subarctic Precambrian Shield: most landforms were created or were strongly affected by Pleistocene to Recent glaciation, which created scoured, rolling hills of some three hundred feet local elevation, often glacially plucked along scarps; some areas are blanketed with glaciofluvial sands. Bedrock structural elements (faults and folds) have caused linear drainage patterns consisting of interconnected lakes and muskeg. Accentuation of

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[1] Preliminary Report of Activities 71-1, Part A, Geol. Surv. Can., 1971: contribution 83.

FIGURE 4

Time-Stratigraphic Units in N.W. Saskatchewan and Adjacent Northwest Territories.

(After McGlynn, 1969)

		Lake Athabasca-Beaverlodge Area	Nonacho-Thekulthili Lake Area	
PROTEROZOIC	NEO HELIKIAN	dykes	dykes	ELSONIAN OROGENY
	PALEO HELIKIAN	Carswell Structure Athabasca Series Martin Fm.	dykes Nonacho Series	
	APHEBIAN	granites & gneisses	granites & gneisses	HUDSONIAN OROGENY
ARCHEAN		Tazin Group	Tazin Group Equivalents	KENORAN OROGENY
AGE				

bedding within the Nonacho Series is attributed to preferential glacial erosion.

Lakes cover about 30% of the thesis area, the largest being Thekulthili Lake, which is a hook-shaped lake lying along the basement-Nonacho Series contact for the most part, some 40 miles in length and from a quarter mile to several miles in width. The lakes here provide easy access to areas of basement-Nonacho Series contacts. A chain of small lakes east of Thekulthili Lake are designated on Map 1 as lakes 1, 2, 3 and 4; the Taltson River flanks the western edge of the study area.

Roughly 60% of the land is covered by subarctic vegetation which occurs in areas of sand or till cover, as well as on some areas of bedrock. The Nonacho Series is often deeply weathered and covered by vegetation growing on these less-resistant sedimentary rocks.

Outcrop exposure is then about 30% of the thesis area. A recent forest fire south of Thekulthili Lake has provided excellent exposure of the gneissic basement complex.

CHAPTER TWO

METHODS OF STUDY

2.1 General Statement

A metamorphic-facies approach to the Nonacho Series problem was initiated by the writer in the winter of 1974-75. Pertinent rock samples collected in 1958 by Burwash were thin-sectioned and examined; preparations were made to re-visit Thekulthili Lake in the summer of 1975. Samples and other field data collected during this field season were processed and synthesized with the 1958 field season rock suite. The combined data yielded sufficient information to give a possible solution to the Nonacho Series problem, relying mainly on petrologic evidence.

2.2 1958 Field Data

Burwash and Taylor collected a suite of rocks along the eastern shore of Thekulthili Lake, mainly for the purposes of radiometric dating but also as samples representative of the lithologies encountered. Aerial photographs used on this study, as well as field notes and early base maps, provided the background data with which to initiate the present study.

Thin sections of selected rocks were made and examined; comparison of the petrology with field descriptions questioned the petrogenetic field interpretations.

2.3 1975 Field Data

Preparation for the 1975 field season involved establishing control from existing field data as well as literature searches. Petrologic data plotted on a base map gave detail to the local geology. The earlier maps of Henderson, Wilson and Mulligan and Taylor were pieced together to give the regional geological setting of the Nonacho Series. Specific target areas were chosen to provide the most geologic data relevant to the problem in the time allotted. Claim sheets provided a series of large-scale maps, which were used for purposes of plotting sample locations in the field. Other preparations included a literature search of papers published on the area.

Profiles across the contact of the Nonacho and adjacent granitoid rocks were planned along the southern extent of the study area. These were designed to cross the contact in a manner which would provide a suite of samples that could show any metamorphic variations along the contact zone. These profiles were spaced from one to five miles apart with special care taken to intersect areas of continuous outcrop where contacts were shown on Wilson's map. When the presence of the lake prevented a continuous profile, islands were used as sample locations to make discontinuities in the profile as small as possible.

Base camp was established at Bigpine Narrows at the south end of Thekulthili Lake in a central location to the area in which profile traverses had been planned. Fly camps by canoe from this base camp provided the necessary mobility.

The data collected along the profiles consisted of photographs of pertinent geological features, field observations, and from 6 to 22 rock samples. Field descriptions of lithologies encountered were supplemented with structural data (strikes of rock units or veins and dykes, dips of bedding or foliation, fractures and shear zones).

The location of sample sites and structural data was plotted on base maps for later reference.

Thin sections cut from the 1975 rock suite were examined with particular emphasis on regional metamorphic textures and mineral assemblages. This data were supplemented by the structural information. Photographs taken in the field of various geological features were used as a permanent record and visual reference along these profiles. Photomicrographs of pertinent metamorphic and textural features were made of both the 1975 and 1958 rock suites. All rocks were then classified according to their petrologic description. Tables of petrologic descriptions with respect to their metamorphic mineral assemblages were made. A map derived from the inferred metamorphic facies was then prepared.

The criteria used for assigning each rock sample to a metamorphic facies were complicated by the discovery of prograde and retrograde polymetamorphic rocks in the sample suites. Therefore the criteria by which the rocks were classified were somewhat modified from more conventional metamorphic facies concepts (Turner, 1969) to include these rock types.

CHAPTER THREE

METAMORPHIC CRITERIA

3.1 General Statement

Recognition of the metamorphic facies present within the suites of rocks collected is fundamental to the approach taken by this thesis in attempting to resolve the Nonacho Series problem. Clearly, a rigidly defined demarcation between regionally metamorphosed and non-metamorphosed rocks is most important. Division of metamorphic facies permits the interpretation of regional metamorphic events. Criteria pertaining to the recognition and division of regional metamorphism are discussed here.

3.2 REGIONAL METAMORPHIC (DYNAMOTHERMAL) EFFECTS

3.2.1 Essentially Unmetamorphosed

A distinct assemblage of metamorphic minerals is the criteria for establishing a lower limit to regional metamorphic effects (Turner, 1967); therefore any sedimentary rock (the Nonacho Series in this instance) lacking the essential mineral assemblages is by definition regarded as unmetamorphosed, irrespective of any gradational nature of thermal-pressure effects occurring within a sedimentary pile. Sericite is a common mineral in greenschist facies metasedimentary rocks. However, it is not diagnostic of this facies, without the presence of an accompanying assemblage

of other greenschist facies minerals, e.g. quartz-muscovite-chlorite-albite.

The zeolite facies, which represents a transition from essentially unmetamorphosed rock to greenschist facies metamorphism is often difficult to recognize in the field. This facies was not recognized in the Nonacho Group, possibly because of compositional constraints.

Textural features associated with sedimentary rocks are well preserved in the unmetamorphosed grade. Bedding, sorting, detrital grain surfaces, imbrication and cross-bedding features are recognizable. There is virtually an absence of regrowth around mineral grains. Sedimentary rocks are considered to be those exhibiting these textural features and lacking a greenschist-facies mineral assemblage.

3.2.2 Greenschist Facies Regional Metamorphism

Significant changes in texture and mineralogy occur within a sedimentary pile subjected to even low-grade regional metamorphism. A new series of distinctive mineral assemblages is most significant (Winkler, 1967, p. 173):

> "Only certain mineral assemblages ... and the conditions under which one commonly-occurring mineral assemblage changes to another one ... permits elucidation of metamorphic conditions".

Kinematic (dynamic) alterations of the original material generally accompany these mineralogical changes.

Primary sedimentary textures are often annihilated by the crushing and re-orientation of mineral grains.

Identification of the lower limits of greenschist-facies metamorphism may be carried out with a reasonable degree of confidence by using a petrographic microscope.

Thin sections reveal the presence or absence of characteristic diagnostic mineral assemblages. Winkler (1967, p. 1974) states:

> "The beginning of the greenschist-facies is characterized by the complete disappearance of prehnite and pumpellyite, at the cost of which, primary zoisite, epidote and actinolite are formed ... typical sedimentary minerals such as kaolinite, glauconite, saledonite and saponite vanish completely only at the beginning of the greenschist-facies".

Minerals common to greenschist P-T conditions, and co-existing as assemblages, include the presence of biotite, epidote appearing with quartz, muscovite, albite (also new microcline feldspar) and usually chlorite, Table I gives common greenschist-facies assemblages.

Chlorite is found not only in the lower greenschist facies, but also in zeolite facies and unmetamorphosed rocks. However, the first appearance of biotite is in the greenschist facies. Winkler (1967, p. 180) gives a reaction showing the earliest formation of biotite, at 360°-370°C and 2000 bars pressures thusly:

$$\text{glauconite} \rightleftharpoons \text{biotite} + \text{muscovite} + \text{K feldspar} + \text{hematite} + \text{quartz.}$$

(phengite is intermediate)

Brown biotite forms at yet higher P-T conditions: (after Hoschel, 1967a, in Winkler, 1967):

$$\text{chlorite} + \text{muscovite} \rightleftharpoons \text{staurolite} + \text{biotite} + \text{quartz} + H_2O$$

$$(540 \pm 15^{\circ}C \ @\ 4000 \text{ bars})$$

Winkler adds, "the assemblage zoisite/epidote and albite does characterize [the greenschist-facies]" (p. 94). Therefore biotite and epidote, associated with compatible complementary mineralogy (Table I), is regarded as indicative of greenschist-facies regional metamorphism.

3.2.3 Amphibolite Facies Regional Metamorphism

"Fundamental changes in diagnostic mineral assemblages marking the boundary between upper greenschist and lower amphibolite facies can be recognized petrographically within a gneissic complex. Strong mechanical deformation is often combined with subsequent recrystallization in the amphibolite facies".[1]

The transition of the greenschist-facies to the amphibolite facies, is marked by changes in mineralogical

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[1] Winkler, H.G.F., 1967. Petrogenesis of Metamorphic Rocks, 2nd Ed., p. 179.

constituents of pelitic and quartz-feldspathic metamorphic rocks.

While chloritoid may be present, it is less abundant in the amphibolite facies than chlorite was in the greenschist-facies. Plagioclase composition of An_{15} or greater is present as opposed to the An_{10} or less (albite) in greenschist-facies rocks. Table I shows metamorphic mineral assemblages generally encountered in these rocks.

The pressure-temperature conditions which result in the formation of the first diagnostic metamorphic mineral assemblages of the amphibolite facies are at about 525°-560°C with 2000-7000 bars H_2O pressure (Winkler, 1967, p. 181). Amphibolite-facies metamorphism is generally the most widespread grade encountered in moderately to deeply eroded regionally metamorphosed terrains.

TABLE I

TYPICAL REGIONAL METAMORPHIC PELITIC MINERAL ASSEMBLAGES
(after Hyndman, 1969)

GREENSCHIST FACIES

I. CHLORITE ZONE

1. Mu-Chl-Qtz-Ab (±Ep-Hem-Mag)
2. Mu-Chl-Qtz-Micro
3. Ca-Chl-Ep-Ab

II. BIOTITE ZONE

1. Mu-Bi-Qtz-Chl
2. Mu-Bi-Qtz-Chl-Ab (Mag)
3. Mu-Bi-Qtz-Chl-Ab-Olig*-Carb
   (*abundant Ca present)
4. Act-Bi-Qtz-Chl-Ep-Olig

III. GARNET ZONE

1. Mu-Bi-Qtz-Ab-Chl-Alm
2. Mu-Bi-Qtz-Olig-Carb (±Alm)
3. Mu-Bi-Qtz-An-Ca-Ank-Chl
4. Hbl-Bi-Qtz-Ab-Chl-Clinoz

AMPHIBOLITE FACIES

I. STAUROLITE ZONE

1. Qtz-Pl-Bi-Gar
2. Qtz±Pl-Bi-Mu-Staur (±Gar±Chl'd)
3. Hbl-Pl-Bi-Ep-Sph±Ap
4. Amph-Pl-Bi-Ep-Di-Ap

II. SILLIMANITE-MUSCOVITE ZONE

1. Qtz-Pl-Bi-Mu-Sil-Gar
2. Qtz-Pl-Bi±Mu-Orthoc (±Ap)
3. Qtz-Pl-Di-Ca-Scap-Graphite (Sph)
4. Qtz-Pl-Hbl (±Bi, Ap, Sph)

III. SILLIMANITE-ORTHOCLASE ZONE

1. Qtz-Pl-Bi-Orthoc-Sil±Gar (±Ap±Sph)
2. Hbl-Pl±Qtz±Bi±Ga±Pyrox

ABBREVIATIONS FOR TABLE I

Minerals:

Amph	Amphibole	Chl'd	Chloritoid	Mag	Magnetite	Sil	Sillimanite
Ap	Apatite	Carb	Carbonate	Micro	Microcline	Staur	Staurolite
Ab	Albite	Ca	Calcite	Mu	Muscovite	Scap	Scapolite
Ank	Ankerite	Clinoz	Clinozoisite	Olig	Oligoclase		
Act	Actinolite	Di	Diopside	Orthoc	Orthoclase		
Alm	Almandine	Ep	Epidote	Pl	Plagioclase		
An	Anorthite	Gar	Garnet	Pyrox	Pyroxene		
Bi	Biotite	Hem	Hematite	Qtz	Quartz		
Chl	Chlorite	Hbl	Hornblende	Sph	Sphene		

3.3 POLYMETAMORPHIC CONSIDERATIONS

3.3.1 General Statement

"There are many metamorphic terrains which have been subjected to several successive metamorphic processes under the P, T conditions of different facies in the course of their geological evolution: the so-called polymetamorphic areas. All traces of the previous episode of metamorphism may not have been entirely eradicated ..."[1]

The remetamorphism of an area to a degree which allows either partial or whole "resetting of the parent-daughter radiometric clocks", is not without textural and mineralogical effects upon those rocks. These textural features and mineralogical changes may permit a petrographer to distinguish polymetamorphic from monometamorphic rocks. J. Krupicka (Burwash and Krupicka, 1969; Sassano and Krupicka, 1972) has outlined practical criteria for recognizing reworked rocks.

Deformation and recrystallization manifests itself both texturally and mineralogically. Deformation by varying degrees of crushing, followed by a preferred sequence of recrystallization, gives a series of recognizably reworked textures - changes in mineralogy which accompany the deformation are also diagnostic of P-T conditions during

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[1] Winkler, H.G.F., 1967. Petrogenesis of Metamorphic Rocks, p. 180-187.

this second metamorphic event. The possibility of superimposing a second metamorphic grade onto a higher, equal, or lower initial metamorphic grade restricts the use of conventional metamorphic facies models. The time period over which deformation and re-crystallization occurs is a largely unknown variable.

Nevertheless, Krupicka has created a working classification system for such rocks, acknowledging the "intriguing resistance they offer to most orderly well-established academic classifications" (Burwash and Krupicka, 1969, p. 1382). An abbreviated classification compiled from several of his publications is given here.

3.3.2 Classification of Deformed and Recrystallized Rocks

Rocks Deformed Without Substantial Recrystallization

a) strained: Pre-deformational texture easily discernible; quartz partly fragmented, micas bent, plagioclase lamellae warped; narrow shear zones.

b) cataclastic: Most pre-deformational grain shapes destroyed, quartz is granulated, micas strongly deformed, feldspars broken and surrounded by mortar, tendency to porphyroclastic texture; numerous rolled out bands and shear zones.

c) mylonitic: Complete destruction of pre-deformational texture, replaced by new kinematic foliation; a fine-grained crush of all minerals contains scattered rounded porphyroclasts.

d) ultramylonitic: crushing of all minerals to a very fine-grained powder, common development of pseudo-tachylitic textures (Moorhouse, 1959, p. 413); both extremes of orientation: massive or with fluidal lamination, frequently exhibiting excellent mechanical mineral separation.

Rocks Deformed With Recrystallization Outlasting Deformation

a) partly recrystallized: A substantial part of the rock is crystallized either as new crystals of the original mineral(s) or as new minerals. Plagioclase remains crushed except in amphibolites.

b) fully recrystallized: rock consists of new or healed crystals of original minerals, as well as new minerals not previously present. In cases where the typically fine-grained mylonitic texture is preserved, the rock is termed blastomylonite.

Microcline, accompanied by myrmekite, is the most critical mineral in this group of rocks. The blasts and clasts of microcline, as well as the nearly ubiquitous myrmekite, both appearing in a wide variety of grain sizes and forms, are readily identifiable characteristics of

reworked rocks. These criteria, once coupled with kinematic textural features, can identify a granitic rock as being undeniably reworked by another metamorphic event.

Other identifiable features of this category are:

a) blurred grain goundaries in hand specimen, diffuse boundaries in thin section.

b) no crystal outlines.

c) bimodal or tri-modal grain size distribution.

d) rolled out lenses, streaks, or bands, often with one or more of above features.

Mechanical Resistance/Recrystallization Series

Krupicka recognizes "a general mechanical resistance series" of the main minerals in a polymetamorphic rock. He also notes a similar relationship with the relative order of ease of recrystallization. These are summarized as follows.

Mechanical Series:

increasing resistance to mechanical deformation

Quartz→(Carbonates)→ Micas, Hornblende→ Feldspars→ Garnet

Recrystallization Series:

increasing difficulty in recrystallization after deformation

Quartz→ (Carbonates)→ Micas, Hornblende→ Feldspars→ Garnet

The use of the preceding classification lacks the precision of the formal petrographic classifications

commonly in use for igneous rocks (e.g. Moorhouse, 1959); however it does allow for a petrogenetic organization and a meaningful classification, of a petrologically complex group of rocks.

Summary of Criteria for Recognizing Reworked Rocks

The identification of polymetamorphic versus monometamorphic rocks in the field is important when attempting to separate an "older" basement rock from a "younger" granite.

Krupicka gives the following features common to most reworked rocks:

a) Textural:

1. hiatal grain-size distribution (except in ultramylonites); commonly a tri-modal grain-size distribution.

2. poikiloblastesis observed in thin section.

3. quartz grains are rodded, streaked; boundaries are indistinct.

b) Mineralogical:

4. microcline porphyroblasts observed growing in rodded, lineated gneiss.

5. presence of an inordinate amount of megacrystic microcline that is surrounded by a plagioclase mortar.

6. presence of myrmekite.

7. mineral assemblages of different metamorphic grades co-existing within one rock; formed during two

metamorphic events which are apparently well-separated in time (e.g. epidote/zoisite and microcline, with relict plagioclase).

These metamorphic criteria may be used to resolve most enigmatic petrographic and petrogenetic situations which cannot be explained by monometamorphism.

3.3.3 Other Metamorphic Considerations

Two special settings for metamorphism are found in the Thekulthili Lake Area, which are not considered under the above headings. Thermal metamorphic aureole from an intrusion affects sedimentary and gneissic country rock in the southwest corner of Thekulthili Lake; reactivated basement gneisses near Salkeld Lake have caused similar thermal-metamorphic features. At the non-conformity between the Nonacho Series sedimentary rocks and the granitic gneiss "basement", there exists a zone of alteration due to pre-Nonacho weathering.

These two metamorphic settings will be discussed with the profiles along which they were found.

CHAPTER FOUR

DETAILED PETROLOGICAL PROFILES

4.1 General Statement

Study of data collected during the 1975 field season consisted primarily of examining a series of samples collected across the mapped Tazin/Nonacho Series/intrusive granite contacts (Map 1) as nearly perpendicular to strike as possible in a series of seven profiles. Samples were collected at intervals ranging from 10 to 500 feet apart. Any apparent change in degrees of metamorphism, cataclasis, alteration, or lithology (or any combination of these factors) is represented by the 1975 sample suite.

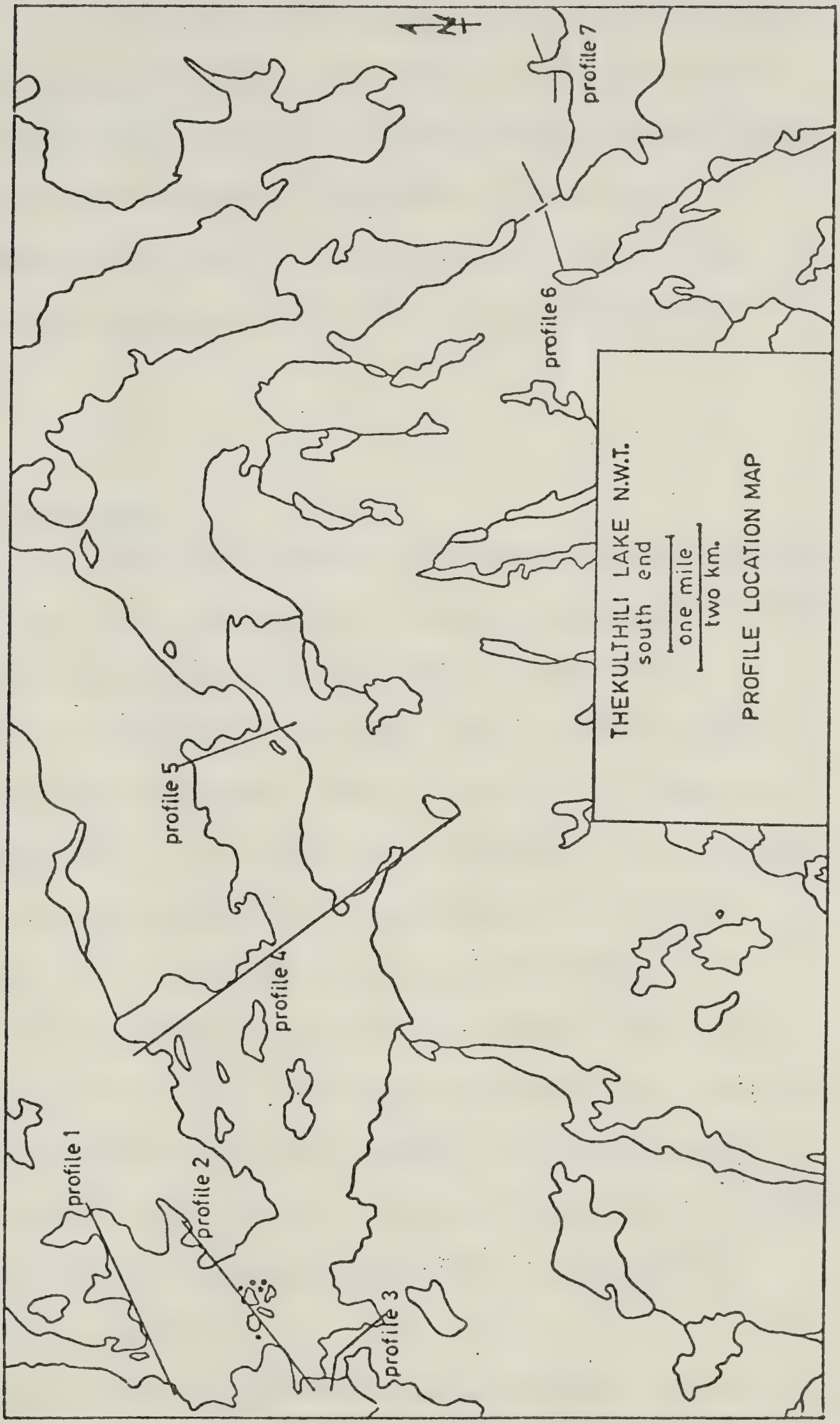
The petrology of these samples describes metamorphic mineral assemblages present in the southern part of the thesis area, and supplements the field data collected at each sample site.

Figure 5 shows the location of Profiles 1 to 7.

4.2 Profile One

4.2.1 Location

Profile One begins in Wilson's "Nonacho Series" (1941) on the east shore of a bay, east of the west channel in the southwestern portion of Thekulthili Lake. The profile extends along the north shore of the bay and



PROFILE LOCATION MAP

Figure 5

across the narrows to the west shore, crossing the contact of the Nonacho Series (Map Unit 5) and the Tazin Equivalent unit (Map Unit 3) and terminating in an area mapped as intrusive granite (Map Unit 9, Map 1). Figure 6 shows the sample sites of Profile One. The Profile is approximately 2 miles long and consists of 19 samples.

4.2.2 Observations

Table II lists the samples examined petrographically (Figure 5), and the metamorphic minerals present in each.

Samples 20-17, 20-16, 20-1b and 11 are a non-metamorphic sedimentary rock, described collectively as a sericitic cobble arkose. This lithology is shown on Map 1 as Map Unit 5. No pertinent metamorphic minerals as described in Chapter Three are present, although sample 20-16 has been penetratively deformed.

Metamorphic minerals appear in samples 20-14 and 20-15, both of which are strongly cataclasized. Chlorite, epidote and zoisite are also present in samples 20-9, 20-8, 20-6 and 20-18, which indicates that these rocks may have been subjected to retrograde lower greenschist regional metamorphism.

In samples 20-19 and 20-20, the presence of relict hornblende altering to epidote and chlorite-(Plate I) amphibolite facies gneisses which have been later retrograded to greenschist-facies (epidote-chlorite).


20-6,7,8,9
20-13,14,15,16
20-10
12
20-11
20-17
20-1b
20-18
20-23,
-24
20-21
20-19,20
Thekulthili Lake
THEKULTHILI LAKE N.W.T.
southwestern area
LOCATION OF PROFILE 1.
0
2000
4000
6000
8000
scale feet

Figure 6

TABLE II

Petrographic Description of Profile One

	Metamorphic Minerals							Sample Number	Thin Section Description (abbrev.)	Map Units:	
	sericite	muscovite	epidote/zoisite	chlorite	biotite	hornblende	microcline			Map 1	Map 2
EAST	•							20-17	sericitic cobble arkose	NONACHO SERIES	5
	•	•						20-16	ser./musc. poor sort. arkose		
	•							20-1b,11	ser. lithic sst.		
	•							20-12	ser. poor sorted lithic sst.		
	•		•					20-14	ep./zoisite ser. meta-sst.		5a
			•	•				20-15	chlor./ep. meta-arkose		
		•	•		•			20-9	musc.-ep.-biot. deformed gneiss		3 or 5a ?
	•	•	•					20-8	ep.-ser.-musc. meta-sed.	TAZIN EQUIV.	
	•		•					20-6	ep.-ser. cataclastic meta-sed.		
			•	•				20-18	ep.-chlor. meta-sed.		
			•		•			20-19	zoisite-carb.-biot. hornfels		3
					•	•		20-20	hbl.-biot. gneiss		
								20-21	ultramylonite, leuco.	INTRUS. GRANITE	6
					•			20-23	biot. meta-siltite (hornfels)		5a
WEST					•		•	20-24	biot.-microcline granite		7

Thesis Map Units: (Map 2)

7. Intrusive Microcline Granite
6. Mylonite
5. Nonacho Series Cobble-Arkose;
   5a. Meta-Nonacho
4. Basic and Metabasic Rocks
3. Retrograde Biotite Gneiss
2. Polymetamorphic and Reworked Gneisses
1. Basement Granite Gneiss

PLATE I

(sample 20-20): Retrograded gneiss has new epidote-chlorite-minerals growing at the expense of hornblende grains. (Magnified 64 x)

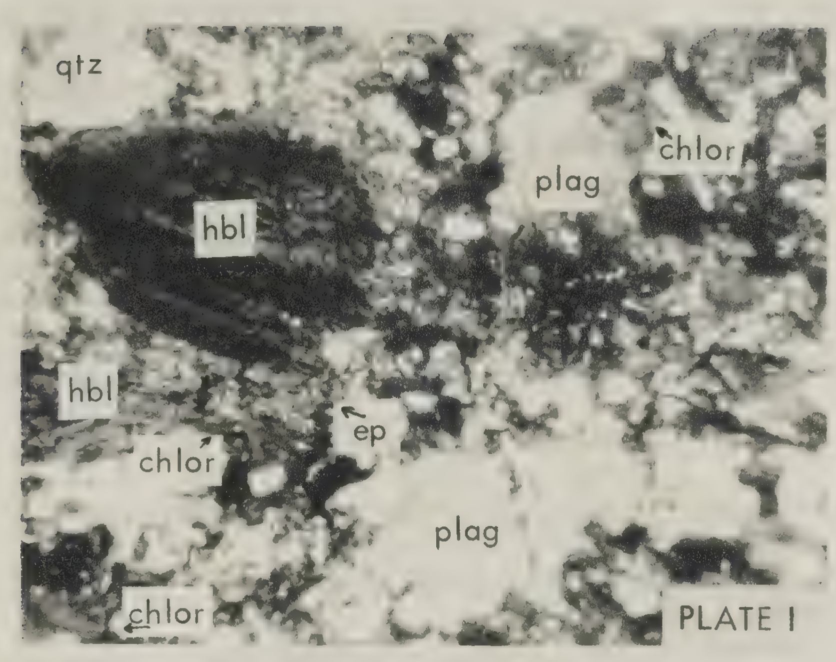


PLATE I

There appears to be little or no structural discontinuity between samples 20-17, the eastern-most site, and 20-20. The Nonacho Series strata and the deformed gneisses are gradational in the field. The profile shows evidence of a marked discontinuity at sample site 20-21, a hand specimen identified in thin section and in the field as mylonite.

On the western side of this structural break, a black, aphantic-rock is found, which was believed to be mylonite as well. Petrographic studies show that sample 20-23 is a biotitic hornfels. (Map Unit 5a).

Contact thermal metamorphism accounts for the fine, equigranular metamorphic texture of this rock. Sample 20-24 was sampled near this hornfels, and consists of a massive leucocratic microcline-rich granite.

The coarse grain-size of the microcline and the massive nature of the rock suggest that this is an intrusive body, responsible for the contact metamorphism of sample 20-23.

4.2.3 Discussion

Profile One crosses a major zone of structural discontinuity which is represented by a mylonite zone and a cataclastic zone of retrograded gneiss. A good deal of the structural relations between the Nonacho Series and the surrounding rocks is present here along a line of near-continuous outcrop.

To the west, a very coarse-grained microcline granite (Sample 20-24) intrudes beside a mylonite belt, creating a biotite hornfels rock (Sample 20-23) and providing the source for a pegmatite vein which cuts the pre-existing cataclastic mylonite zone (Sample 20-21). The shear zone appears to be a weak crustal area in which the granite was emplaced. The thermal effects of this granite, as well as possibly related kinematic effects, are evident in samples 20-20 through to 20-14.

The retrograde monometamorphic gneiss represented by those samples has undergone at least one period of cataclasis after its formation. Formation of greenschist-facies mineral assemblages at the expense of amphibolite-facies minerals is apparent in samples 20-19 and 20-20. The heat source for this retrogressive reaction was likely the western pluton.

The contact between gneiss-cataclasites and Nonacho strata is obscured in the field by the similarity between cataclastic blocky rocks and conglomerates derived from local basement material. A sharp cut-off in metamorphic mineral assemblages at the Nonacho Series contact is noted in thin section, although texturally the cataclasite and the peripheral Nonacho Series samples (Sample 20-12) differ little in their degree of deformation. This suggests a final brittle deformational event, perhaps related to the final folding of the Nonacho Series occurring here.

The probable sequence of events explaining the location and mineralogy of the various rock types is as follows:

1. Existence of an early mylonite zone, cutting amphibolite-facies gneisses.

2. Establishment of the basinal structure into which the Nonacho Series was deposited.

3. Reactivation of the mobile belt, causing cataclasis in nearby gneisses and some deformation of peripheral Nonacho strata.

4. Intrusion of granite body accompanying an uplift in the west, which resulted in greenschist-facies mineral assemblages in the mobile zone, hornfels at the contact, and a cross-cutting pegmatitic vein in the recrystallized cataclastic mylonite belt.

Further evidence of the intrusive nature of this late stage granite pluton is discussed in Profile Two.

4.3 Profile Two

4.3.1 Location

Profile Two (shown in Figure 7) is located about one mile south of Profile One, in the southwestern portion of Thekulthili Lake. It is constructed along the south shoreline of a prominent bay in the east, crosses the


Thekulthili Lake
20-1,2
20-4,5
20-3
19-15,16
19-14
19-12,13
THEKULTHILI LAKE N.W.T.
southwestern area
LOCATION OF PROFILE 2.
0
2000
4000
6000
8000
scale feet

Figure 7.

west channel on a series of islands, and continues to the southwest shore of the lake. This profile crosses contacts shown on Map 1, between the Nonacho Series (Unit 5), the Tazin Equivalent (Unit 3) and the intrusive granite (Unit 9). The profile consists of 9 samples collected over a distance of about 2 miles.

4.3.2 Observations

Samples 20-5 to 20-1 have been mapped as Nonacho Series sedimentary rocks (Wilson, 1941). Thin section studies show the presence of epidote in sample 20-1. Therefore, it is possible to consider this cobble-arkose (sample 20-1) as essentially weakly metamorphosed. Samples 20-3 and 20-4, which are located near this site, show no new regional metamorphic minerals. Chlorite and sericite are present in sample 20-5.

Epidotic and chloritic mineral assemblages and the presence of relict hornblende on the reefs and islands in the west channel identify these rocks are retrograde metamorphic. Hornblende is found in sample 19-15, as well as chlorite and epidote.

The west end of Profile Two shows a continuation of the massive, very coarse-grained, microcline granite observed on Profile One. Samples 19-13 and 19-12 are both samples of this intrusive granite.

TABLE III

Petrographic Description of Profile Two

	Metamorphic Minerals							Sample Number	Thin Section Description (abbrev.)	Map Units:	
	sericite	muscovite	epidote/zoisite	chlorite	biotite	hornblende	microcline			Map 1	Map 2
EAST	•			•				20-5	chloritic sericitic sst.	NONACHO SERIES	5
	•							20-4	cobble in a sericitic arkose		
	•							20-3	sericite sandstone		
	•							20-2	sericite sandstone		
	•		•					20-1	epidote-sericite meta-sst.		5a
			•	•	•			19-15	chlor.-biot.-ep. plagic meta-amphib.	TAZIN EQUIV.	4
				•		•		19-14	retrograde c. gr. amphib.		
WEST							•	19-13	microcline granite	INTRUS GRAN-ITE	7
							•	19-12	microcline granite		

Thesis Map Units: (Map 2)

7. Intrusive Microcline Granite
6. Mylonite
5. Nonacho Series Cobble-Arkose;
   5a. Meta-Nonacho
4. Basic and Metabasic Rocks
3. Retrograde Biotite Gneiss
2. Polymetamorphic and Reworked Gneisses
1. Basement Granite Gneiss

4.3.3 Discussion

It is apparent that sample 20-1, an epidote-sericite meta-sandstone, has been slightly affected by a regional metamorphic event, likely the same event which was responsible for the retrograde mineralogy present in the basic rocks situated in close proximity on the islands (see Figure 6). A thermal gradient similar to that believed present at Profile One appears to have affected the rocks in this area in a similar manner. Profile Two shows a more distinct metamorphic break than Profile One, owing likely to the presence of the lake.

The presence of a granite intrusion to the west increases the similarity of Profile Two to Profile One.

4.4 Profile Three

4.4.1 Location

Profile Three (Figure 8) straddles a creek draining into the southwestern extremity of Thekulthili Lake. It crosses the contact of the intrusive granite and the Tazin Equivalent unit. An extension of this profile is made by including a sample site at the head of a bay about one mile east of the creek, making the total length along which the ten samples were collected about 1-1/2 miles.

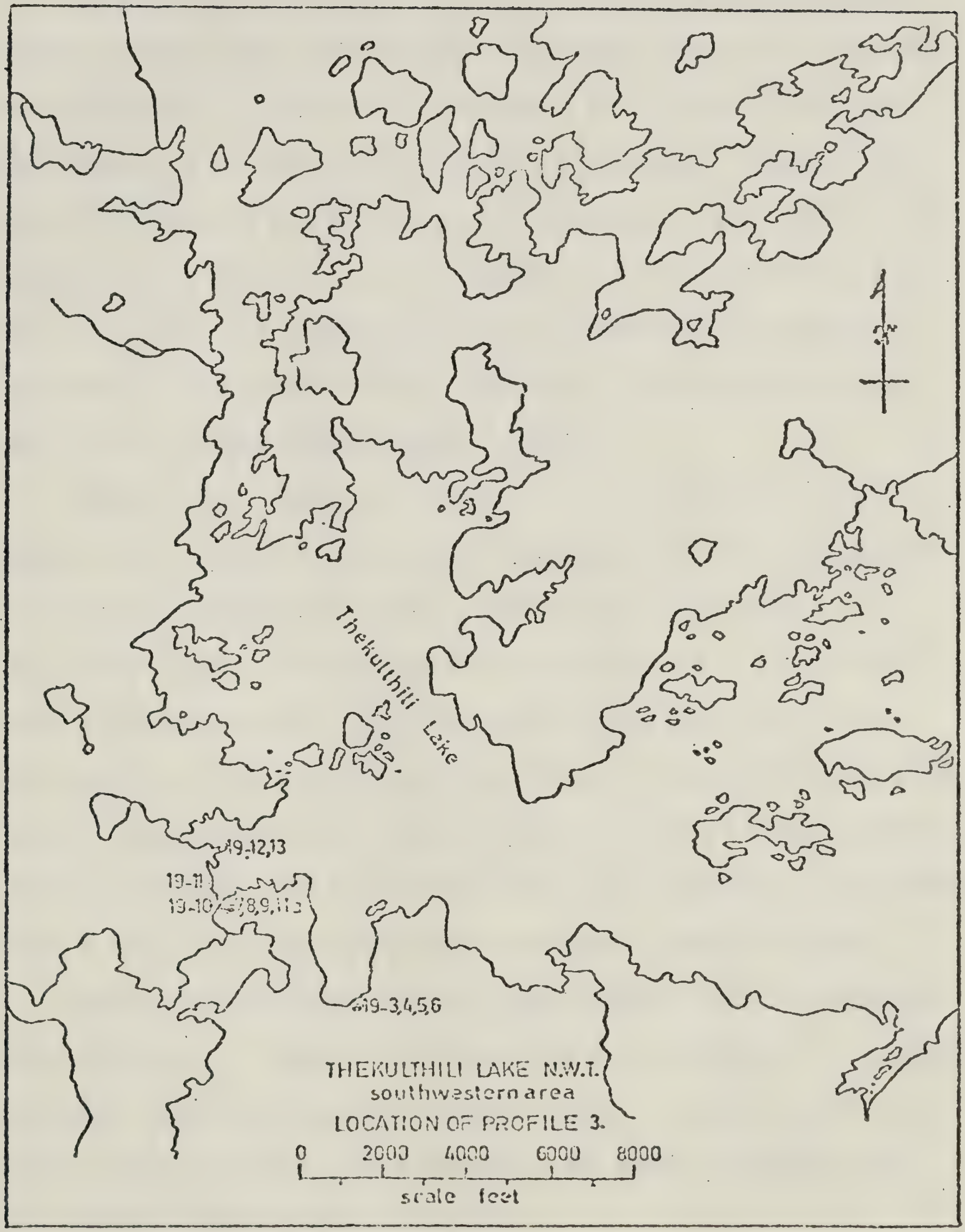

N
Thekulthili Lake
19-12,13
19-11
19-10
7,8,9,11a
19-3,4,5,6
THEKULTHILI LAKE N.W.T.
southwestern area
LOCATION OF PROFILE 3.
0
2000
4000
6000
8000
scale feet

Figure 8.

4.4.2 Observations

Table IV shows the scatter of diagnostic metamorphic minerals found in the samples which comprise this profile.

Samples 19-3, 4 and 6 are collected at the farthest distance away from the contact with the intrusive granite. The presence of chlorite in samples 19-3 and 4 indicate that these are likely retrograded gneisses. Sample 19-6 has chlorite and biotite minerals present, and also a new growth of microcline. All samples are from the same outcrop. Leucocratic granitic veins intrude these older gneisses in a plastic state, causing a slight displacement of the discordant granite vein.

Nearer the contact, samples 19-11a, 19-9 and 19-7 indicate the presence of further amphibolite facies gneissic or granitic intrusive rocks within the older Tazin Equivalent unit. The retrograded nature of a hornblende gneiss (sample 19-8), now containing epidote, chlorite and biotite, likely occurred because of the influence of a second thermal episode. This event is most likely related to the intrusion of the microcline-rich granite to the west. Sample 19-12 is part of this intrusive granitic body.

Upper greenschist-facies paragneisses are found near the intrusion. Sample 19-10 is one such medium- to coarse-grained foliated biotite gneiss. Also, a more hornfelsic gneiss, sample 19-11, was present in close proximity to the granite (Map Unit 7, Map 2).

TABLE IV

Petrographic Description of Profile Three

	Metamorphic Minerals							Sample Number	Thin Section Description (abbrev.)	Map Units:	
	sericite	muscovite	epidote/zoisite	chlorite	biotite	hornblende	microcline			Map 1	Map 2
EAST	•	•			•		•	19-6	leuco. biot. qtz.-monz. gneiss	TAZIN. EQUIV.	3
	•			•	•		•	19-4	leuco. granodioritic gneiss		
	•			•				19-3	leuco. qtz.-dioritic gneiss		
	•						•	19-11a	leuco. microcline granite		7
	•						•	19-9	leuco. granite		
	•		•	•	•	•		19-8	retrograde amphib. gneiss		3
	•				•			19-7	biot.-andesine granite		7
	•				•			19-10	biot. quartz-monz. gneiss		
						•	•	19-11	clinopyrox.-hbl.-hornfelsic gneiss	INTRUS. GRANITE	3
WEST	•			•	•		•	19-12	intrusive granite gneiss		7

<u>Thesis Map Units: (Map 2)</u>

7. Intrusive Microcline Granite
6. Mylonite
5. Nonacho Series Cobble-Arkose;
   5a. Meta-Nonacho
4. Basic and Metabasic Rocks
3. Retrograded Biotite Gneiss
2. Polymetamorphic and Reworked Gneisses
1. Basement Granite Gneiss

4.4.3 Discussion

It is apparent that Profile Three shows a different set of field relations than Profiles One and Two.

The Nonacho Series (Map Unit 5, Map 2) is not recognized on the southern shore of Thekulthili Lake; instead several types of biotite gneisses, intruded by granite veins, are present. The thermal metamorphic effects of the granitic pluton are much more profound here. It is felt that the more brittle nature of these gneisses compared to the sedimentary rocks farther northwest, combined with the possibility that the gneisses may have been at depth when intruded, has promoted the spread of these granitic offshoots from the main pluton.

Nearer the contact, the west-dipping gneisses reverse dip (Map 2). The intrusion of the microcline granite may have caused the hornfelsic nature of the hornblende gneiss. Sample 19-11 next to the intrusion is evidence of thermal metamorphism, not unlike sample 20-23 of Profile One. It may be concluded that this one granite intrusion has thermally affected both the Nonacho Series (Map Unit 5) and the Tazin Equivalent gneisses (Map Unit 3) shown on Map 1. The intrusion is therefore younger than both those map units.

4.5 Profile Four

4.5.1 Location

Plate II gives an aerial view of Profile Four (Figure 9) looking northwest across Thekulthili Lake from its southern-most limit. It follows a northwest-trending fault lineation from a point near the head of a bay to the north, and along the east shore of that bay. On the south shore, it follows an extension of that lineation down a bay and terminates at the second of a series of small lakes. The northern part of Profile Four has been mapped (Wilson, 1941) as Nonacho Series, and the southern half has been mapped as Tazin Equivalent (Map 2). About three-quarters of a mile of lake separates the two parts of the Profile: total length is about 3-1/2 miles; 22 samples were taken here.

4.5.2 Observations

Samples 21-1 to 21-5 (Table V) show no metamorphic mineral assemblages are present in these sericitic sandstones (see Plate III). Quartz grains remain distinct, detrital muscovite is present, and the only mineral which was formed after deposition appears to be sericite, which likely formed from pre-existing clay minerals.

Sample 21-6 is indistinguishable in the field from the preceding five samples, but thin section examination shows epidote to be present. Plate IV shows epidote grains growing around a detrital quartz grain, and sericite

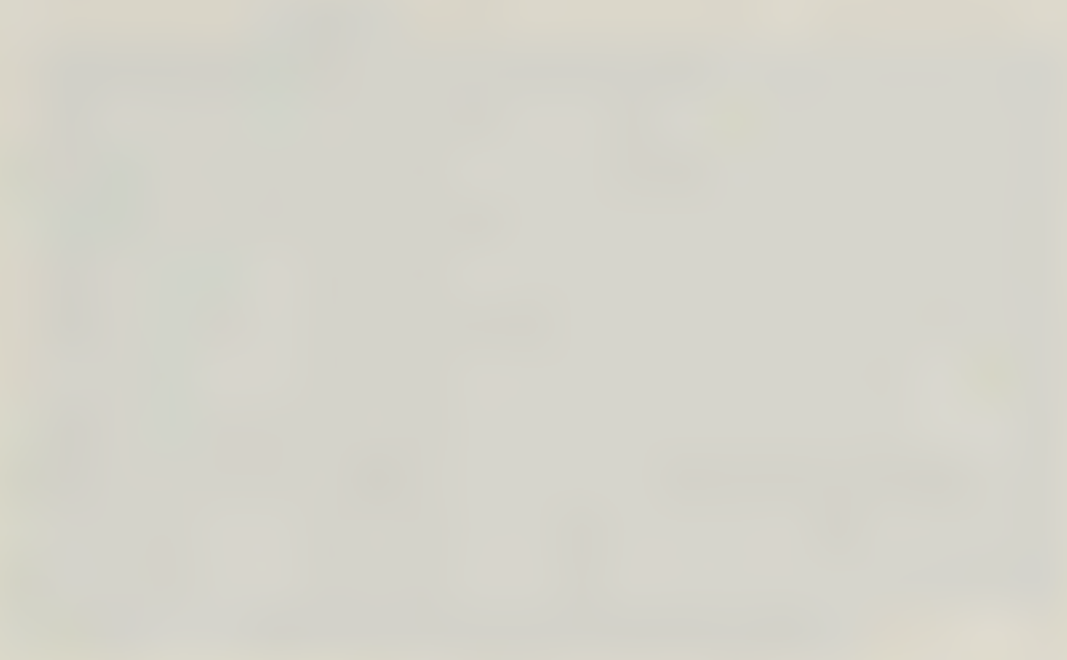


PLATE II

(Profile 4): An aerial view of Profile Four, looking northwestward across Thekulthili Lake from the gneissic complex to the Nonacho Series on the distant shore.

PLATE II


21-1
21-2
21-3
21-4
21-5
21-6
Thekulthili Lake
Bigpine Narrows
21-13
21-12
21-9,10,11
21-7
27-12
-8
-9
-5
27-1-4
27-10
27-6, 7
N
THE KULTHILI LAKE N.W.T.
southcentral area
LOCATION OF PROFILE 4.
0
2000
4000
6000
8000
scale feet

Figure 9.

TABLE V

Petrographic Description of Profile Four

	Metamorphic Minerals: sericite	muscovite	epidote/zoisite	chlorite	biotite	hornblende	microcline	Sample Number	Thin Section Description (abbrev.)	Map Units: Map 1	Map Units: Map 2
NORTHWEST	:							21-1	sericitic sandstone	NONACHO SERIES	5
	•							21-2	sericitic sandstone		
	•							21-4	sericitic sandstone		
	•							21-5	sericitic sandstone		
	•		•					21-6	epidote sericite meta-sandstone		5a
	•		•	•				21-13	sericitic meta-sedimentary rock	TAZIN EQUIVALENT GNEISS	3
	•			•	•			21-12	biot. gneiss		
	•		•	•	•		•	21-9	biotite plagic. gneiss		
	•		•	•	•		•	21-10	p-blastic gneiss		
	•		•	•				21-11	retro. ep.-ser.-chlor. gneiss		
	•			•				27-12	chloritic plagic. gneiss		
	•		•	•	•	•		21-7	ep.-hbl.-biot. gneiss (retrog.)		
	•		•	•				27-8	leuco. plagic. chlor. ep. gneiss		
SOUTHEAST			•		•	•	•	27-9	p-blas. biot.-microcline gneiss		2
			•		•	•	•	27-10	ep.-hbl.-biot.-microcline gneiss		
			•		•		•	27-5	hbl.-ep.-biot. qtz.-rich gneiss		
	•		•		•	•	•	27-1	hbl.-microcline-plag. gneiss		
			•		•	•	•	27-2	ep.-hbl.-biot.-microcline gneiss		
			•		•	•	•	27-3	ep.-hbl.-biot.-microcline gneiss		
			•		•	•	•	27-4	hbl.-biot.-K-fd. plag. gneiss		
			•		•	•	•	27-6	p-blas. ep.-hbl.-biot. micro. gneiss		
			•		•	•	•	27-7	leuco. biot.-microcline gneiss		

Thesis Map Units: (Map 2)

7. Intrusive Microcline Granite
6. Mylonite
5. Nonacho Series Cobble-Arkose;
   5a. Meta-Nonacho
4. Basic and Metabasic Rocks
3. Retrograded Biotite Gneiss
2. Polymetamorphic and Reworked Gneisses
1. Basement Granite Gneiss

PLATE III
(Sample 21-5): Nonacho Series conglomerate, showing sericitization of matrix minerals but no metamorphic minerals. Detrital grain boundaries are evident. (Magnified 64 x).

PLATE IV
(Sample 21-6): Nonacho Series conglomerate with presence of new epidote grains suggests lower greenschist facies metamorphism, although detrital grain boundaries are preserved. (Magnified 64 x).

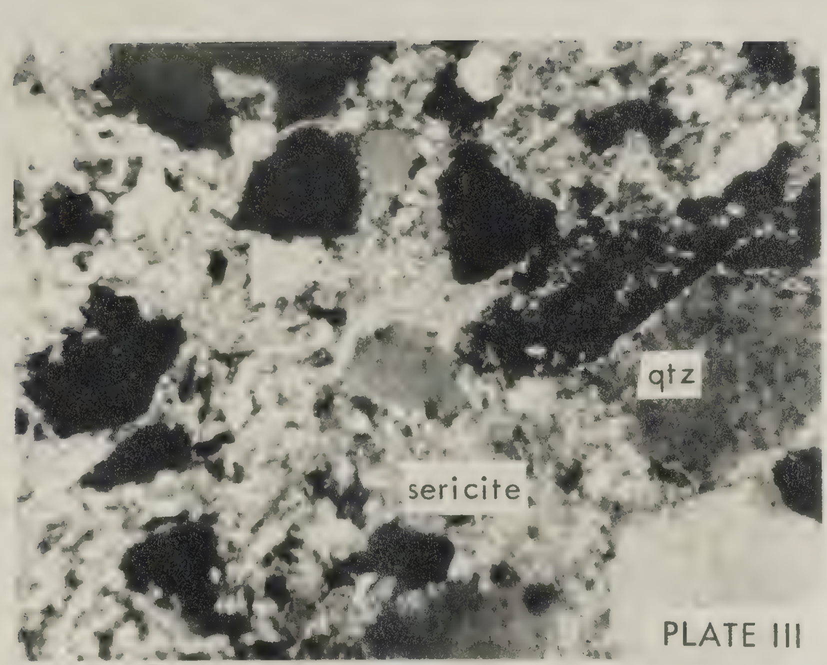


PLATE III

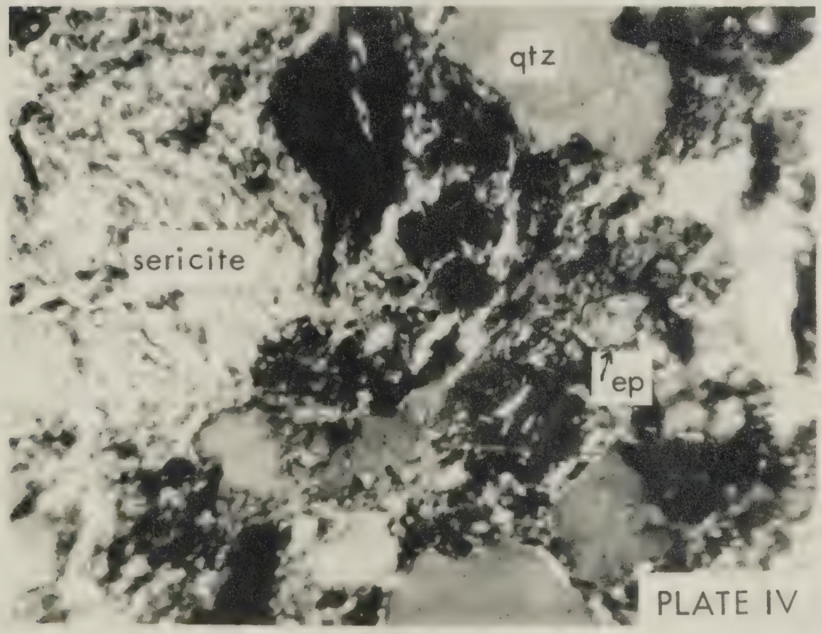


PLATE IV

wrapping completely around a detrital muscovite grain. Epidote in this sample marks the beginning of the weak regional metamorphic zone present along this Profile.

Sample 21-13, collected on the south shore (Figure 8), contains epidote and chloritic minerals in what appears in the field to be a biotite gneiss. Sample 21-12, 21-9 and 21-10 are all chlorite and epidote-bearing retrograded paragneisses. There are some possible relict clasts in these gneisses.

The mineralogy of samples 21-12, 21-7 and 27-8 include chlorite. Therefore these gneisses are regarded as part of the same greenschist-facies, retrograded gneissic unit, which extends westwards towards Profile Three and eastwards towards Profile Five and Six. The disappearance of chlorite and the marked abundance of hornblende and microcline in sample 27-9 over a very short distance marks the beginning of an amphibolite-facies regional metamorphic unit of gneisses.

There are several other notable features which occur at the greenschist/amphibolite-facies boundary. The strike of higher grade gneisses changes by about 20 degrees east and the dip of these gneisses changes from 40° dips to 30° dips. Microcline porphyroblasts are noted growing in lineated ribbon-quartz and hornblende-bearing

gneisses. The higher-grade gneisses may have a second foliation, superimposed upon the primary foliation (Plate V, sample 27-10). Near the boundary between the two gneisses, the retrograde gneisses appear to be sheared and the reworked gneisses (Map 2, Map Unit 2) are cross-cut by epidote veinlets. Clearly, the higher-grade gneiss encountered here is different from that observed along Profiles One to Three.

Samples 27-1 to 27-7 are amphibolite-facies hornblende-biotite gneisses, usually lineated and often with microcline porphyroblasts (Plate VI) being formed at the expense of plagioclase. Samples 27-9 and 27-10 show similar textural and mineralogical features. The textural features shown by all samples of medium-grade, and collected south of the gully indicate that these gneisses are polymetamorphic in origin, as opposed to the adjacent retrograde gneisses. The criteria used in this determination are given in Chapter Three.

4.5.3 Discussion

Profile Four shows the existence of an unmetamorphosed unit, as well as a retrograded greenschist-facies and amphibolite-facies metamorphic unit. The effects of a thermal event, as reflected in the new metamorphic mineral assemblages present here, decreases towards the north. Sample 21-6 confirms the earliest evidence (Profile

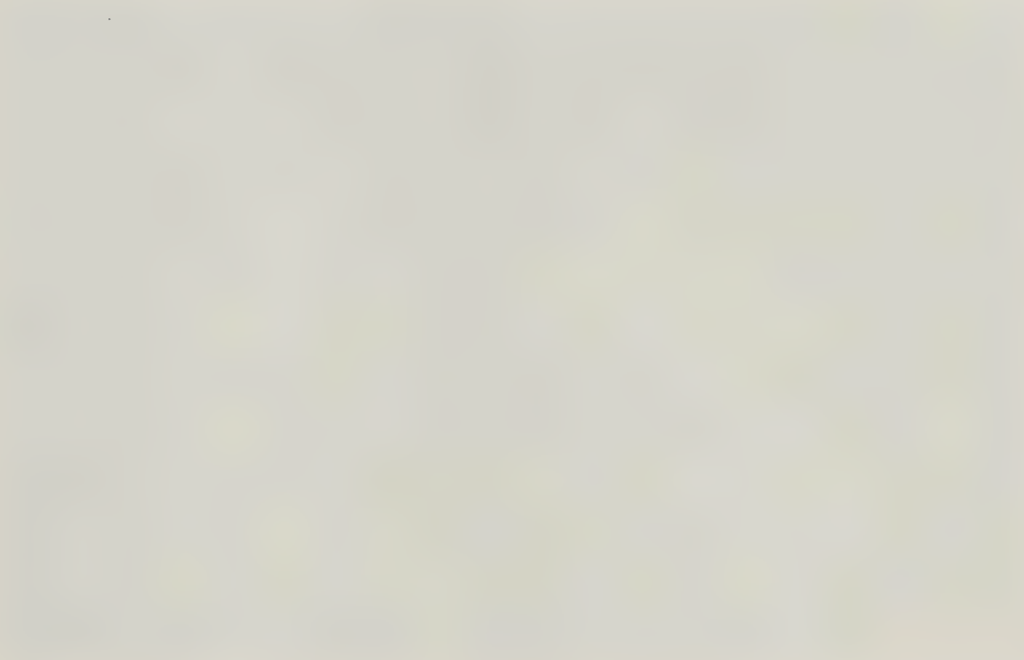


PLATE V

(Sample 27-10): Two orientations of biotite grains are present in this polymetamorphic gneiss (accentuated by ink lines, which suggests a second foliation superimposed upon the primary foliation. (Magnified 64 x).

PLATE VI

(Field photograph): Microcline porphryoblasts are large and numerous in the polymetamorphic hornblende-microcline gneiss (coin has 25 mm diameter).

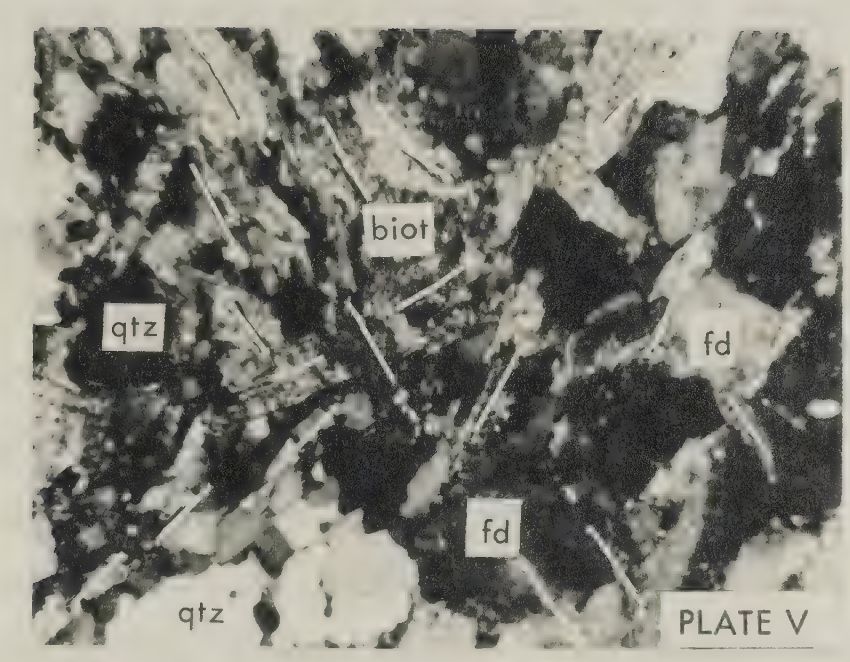


PLATE V

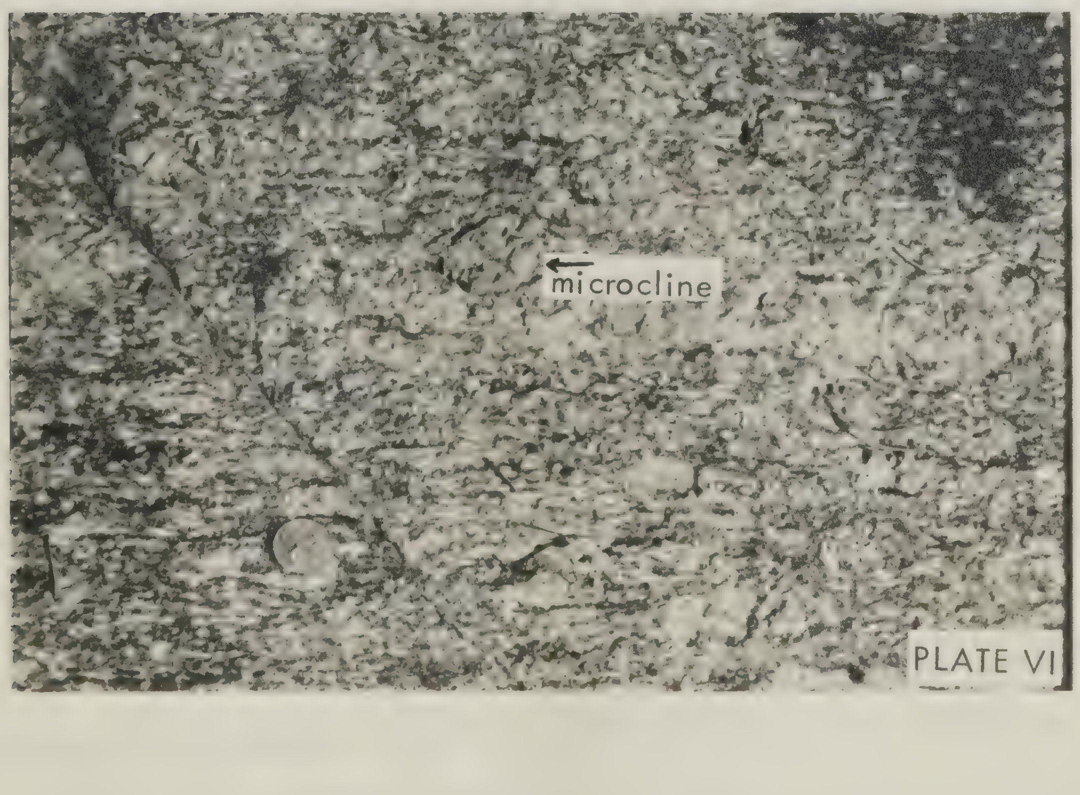


PLATE VI

One) that some parts of the Nonacho Series (Map 1) are indeed metamorphosed. Relict clasts present in retrograde gneisses (sample 21-9) in the Tazin Equivalent map unit (Map 1) suggest that this low-grade paragneissic unit may have been a metamorphosed conglomerate unit, older than the Nonacho Series.

The hornblende-microcline porphyroblastic gneisses present at the south end of Profile Four are believed to be polymetamorphic in nature, as earlier stated. The altered and sheared nature of the contact suggests that the retrograde gneiss to the north of this unit behaved in a mechanically weaker manner than the polymetamorphic unit, although epidote veining near the contact is evidence of some alteration.

It appears then, that the polymetamorphic gneiss represents a pre-existing crystalline basement upon which a sedimentary sequence was deposited. Both units were then metamorphosed. The present-day contact between the two units is a metamorphosed expression of the non-conformity which must have existed before the last major regional metamorphic event.

An arcuate lineation coinciding with this contact noted at Profile Four is observed on aerial photographs, wrapping around the northern extent of this polymetamorphic gneiss unit. This lineation may be the litho-

logical contact wrapping around a polymetamorphic gneissic domal feature, lying immediately south of Thekulthili Lake. The core of this southern thermal dome is interpreted as reworked basement gneiss, which is enveloped by a retrograde monometamorphic gneissic unit which plunges under Thekulthili Lake. A long cooling history during remetamorphism of the gneiss is a possible cause of retrogression of once amphibolite-facies minerals to greenschist-facies.

4.6 Profile Five

4.6.1 Location

Profile Five is shown in Figure 10 to cross Thekulthili Lake immediately west of Bigpine Narrows. The sample sites are located along the western edge of a north-south striking shoreline, on several reefs in the narrows including an island referred to here as Bigpine Island, and on the south shore of Thekulthili Lake. Map 1 shows this profile beginning well within the Nonacho Series to the north and extending into the Tazin Equivalent unit mapped on the south shore. It is about 1 mile long and consists of 10 samples.

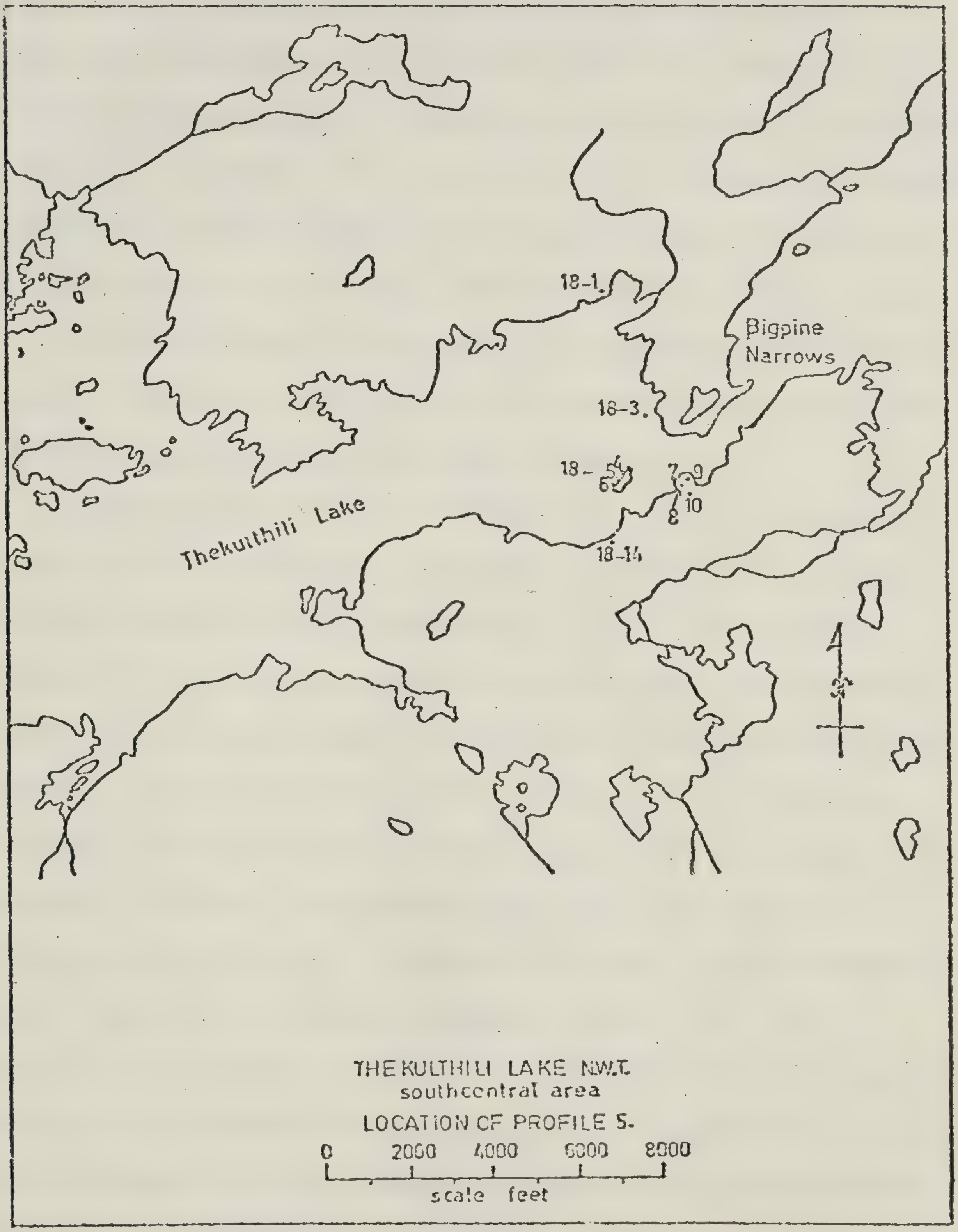

18-1.
Bigpine
Narrows
18-3.
18-5
6
7-9
10
8
18-14
Thekulthili Lake
THEKULTHILI LAKE N.W.T.
southcentral area
LOCATION OF PROFILE 5.
0
2000
4000
6000
8000
scale feet

Figure 10.

4.6.2 Observations

Sample 18-1 is a medium-grained sericitic arkosic sandstone. Sample 18-3 is described as a sericitic chlorite sandstone-conglomerate (Table VI), and is considered as essentially unmetamorphosed because no epidote/ zoisite is present. The chlorite in this sample is likely formed from pre-existing clay minerals much the same as the sericite also present, under diagenetic conditions.

Bigpine Island consists of low-grade epidote/zoisite-chlorite-biotite meta-basic and/or meta-sedimentary rocks. Hornblende is present in sample 18-5.

The southern shore of Thekulthili Lake at Bigpine Narrows is comprised of gneisses in which appear greenschist-facies mineral assemblages, e.g., sample 18-14. Sample 18-7 is a muscovite-zoisite-biotite gneiss, which contains streaked quartz-feldspathic blebs reminiscent of granitic cobbles in the cobble arkoses of the Nonacho Series. Hornblende and epidote are present in sample 18-8; however petrologic evidence shows that this unit is a retrograde paragneiss. Samples 18-9 and 18-10 represent more leucocratic gneisses present (Table VI). All samples of gneisses examined on the south shore of Profile Five are considered to have been of the amphibolite-facies in origin because of the high An content (An_{30}) plagioclase present, retrograded to greenschist-facies.

TABLE VI

Petrographic Description of Profile Five

	Metamorphic Minerals							Sample Number	Thin Section Description (abbrev.)	Map Units:	
	sericite	muscovite	epidote/zoisite	chlorite	biotite	hornblende	microcline			Map 1	Map 2
NORTH	•							18-1	med. gr. sericitic arkose	NONACHO SERIES	5
	•			•				18-3	carbonate sericitic chlor. sst.		
	•		•	•	•			18-4	ser.-ep./zois.-biot./chlor. meta-diabase	TAZIN EQUIVALENT	4
	•		•		•	•		18-5	hbl.-biot.-ep./zois. retro. amphib.		
	•		•		•	•		18-6	chlor./biot.-ep./zois.-ser. metased rock		
		•	•	•	•			18-7b	musc.-zois.-biot. gneiss		3
			•	•		•	•	18-8	ep.-hbl. paragneiss		
		•	•	•	•		•	18-9	chlor.-biot. musc. leuco. gneiss		
			•	•				18-10	chlor.-ep.-plagioclase gneiss		
SOUTH	•		•	•	•		•	18-14a	zois./ep.-chlor.-micro. paragneiss		

Thesis Map Units: (Map 2)

7. Intrusive Microcline Granite
6. Mylonite
5. Nonacho Series Cobble-Arkose;
   5a. Meta-Nonacho
4. Basic or Metabasic Rock
3. Retrograded Biotite Gneiss
2. Polymetamorphic and Reworked Gneisses
1. Basement Granite Gneiss;
   1a. (altered)

4.6.3 Discussion

Profile Five (Figure 10) shows some similarities to previously studied profiles (Figure 7). Nonacho Series sedimentary rock units give way to calcium-rich meta-basic and possibly meta-sedimentary rocks found on islands, here and along Profile Two. Retrograde regional or thermal is present at the metamorphic (south) end of this Profile. Profile Five correlates well with the units defined along Profile Four. The retrograde gneiss units containing possible relict granitic clasts are found occupying the sample stratigraphic horizon with respect to the southern thermal dome of metamorphic rocks, described at Profile Four. Again, a thermal gradient appears to decrease towards the Nonacho Series map unit (Map 1), where it terminates abruptly.

4.7 Profile Six

4.7.1 Location

Figure 11 gives the location of Profile Six, consisting of 21 samples, which crosses the eastern contact of the Tazin Equivalent unit and the Nonacho Series (Map 1). The sample sites begin in the Nonacho Series about a half mile from the contact, which coincides with a portage trail between Thekulthili Lake and Lake 4 (Map 2). The Profile extends 3/4 mile into the Tazin Equivalent to a small lake. The only significant break in outcrop exposure occurs on

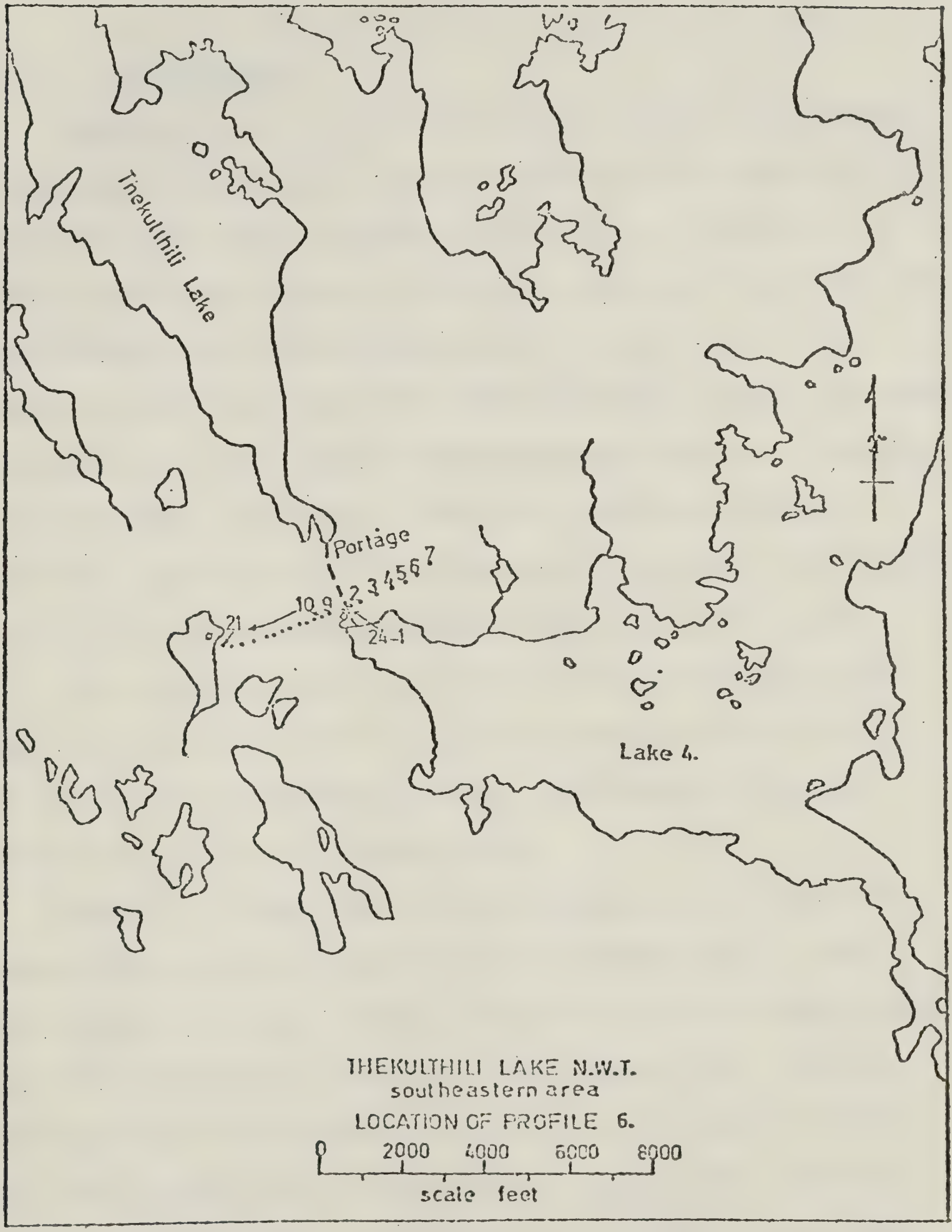

Thekulthili Lake
Portage
2 3 4 5 6 7
10 9
21
24-1
Lake 4.
THEKULTHILI LAKE N.W.T.
southeastern area
LOCATION OF PROFILE 6.
0 2000 4000 6000 8000
scale feet

Figure 11.

the mapped contact, where the two units are separated by about 30 feet of muskeg.

4.7.2 Observations

Sample 24-7 is a sericitic iron-stained conglomerate sandstone, essentially unmetamorphosed, and therefore included in the Nonacho Series (Table VII). Samples 24-6 and 24-5a show the presence of chlorite only, and are therefore considered to be sedimentary rocks. Sample 24-5a consists for the most part of a fine-grained, felted mass and is believed to be weakly metamorphosed regolith. Samples 24-3 and 24-4, collected closer to the Tazin-Nonacho contact, still show no new metamorphic mineral assemblages, and so all are considered Nonacho Series lithologies.

The appearance of zoisite and the re-appearance of chlorite in samples 24-2 and 24-1, both collected east of the Tazin Equivalent map unit, indicates the weak effects of regional metamorphism.

Table VII shows the slight transition in diagnostic metamorphic minerals which occurs between sample 24-1, and 24-8b, the first sample taken in the Tazin Equivalent map unit, less than 100 feet from sample 24-1. Sheared, chloritic and epidote/zoisite-bearing cataclastic rocks are encountered in this map unit. Metamorphic minerals are present in rocks which possess cataclastic textures. Sample 24-15, described in Table VII as a carbonate-biotite gneiss, shows no sedimentary features and is

TABLE VII

Petrographic Description of Profile Six

	Metamorphic Minerals							Sample Number	Thin Section Description (abbrev.)	Map Units:	
	sericite	muscovite	epidote/zoisite	chlorite	biotite	hornblende	microcline			Map 1	Map 2
EAST	•							24-7a	ser. Fe-stained cgl.-sst.	NONACHO SERIES	5
	•			•				24-6	chlorite-sericite sst.		4
	•			•				24-5a	regolithic material		
	•							24-4	sericitic pyritic cobble sst.		5
	•							24-3	sericitic silty arkose		
	•		•					24-2	zoisite-sericite regolith		5a
								24-1	sheared meta-arkose		
	•		•	•	•			24-8b	chlor.-ser. meta-cgl.	TAZIN EQUIVALENT	
	•		•	•			•	24-9	chlor. meta-arkose		
			•	•			•	24-10	carb.-chlor deformed meta-arkose		
	•			•			•	24-11	chlor. carb. meta-arkose		
	•	•	•	•			•	24-12	carb.-ser./musc. chlor.-zois. meta-arkose.		
	•			•	•		•	24-13	p-blas. ser.-biot.-chlor. paragn.		3
	•			•	•		•	24-14	biot.-ser./chlor. meta-arkose		
	•	•	•	•	•			24-15	carbonate biotite paragn.		
	•		•		•			24-16	ser.-biotite paragneiss		
					•			24-17	leuco. plag. (86%) gneiss		
								24-18	plagioclase (99%) gneiss		
WEST	•	•	•		•			24-19	musc.-biot. rodded gneiss		
	•	•	•		•			24-20	musc.-biot. plagic. gneiss		
			•		•			24-21	ep.-biot. plagic. gneiss		

Thesis Map Units: (Map 2)

7. Intrusive Microcline Granite
6. Mylonite
5. Nonacho Series Cobble-Arkose;
   5a. Meta-Nonacho
4. Basic and Metabasic Rocks
3. Retrograded Biotite Gneiss
2. Polymetamorphic and Reworked Gneisses
1. Basement Granite Gneiss

classified as a retrograde gneiss, because secondary chlorite is present in thin section.

Station 24-16 marks the disappearance of chlorite and the beginning of upper greenschist or amphibolite-facies gneisses. Samples 24-16 to 24-21 show similar metamorphic mineral assemblages to those considered as greenschist-facies cataclastic rocks, but all lack chlorite.

The rocks described in Table VII indicate a monometamorphic history of formation, which has included cataclasis.

4.7.3 Discussion

A transition from essentially unmetamorphosed to weakly metamorphosed sedimentary rocks is again apparent here at Profile Six. That unit mapped by Wilson (1941) as Nonacho Series (Map Unit 5, Map 1) is shown to contain metamorphic minerals in samples collected near the mapped contact. The gneisses of the Tazin Equivalent, which are in very close proximity to the Nonacho Series, begin as sheared retrograded cataclastic gneisses and proceed to amphibolite-facies gneisses farther from the contact. No structural break is apparent at the mapped contact. It is postulated that shearing within the metasedimentary unit has resulted in a mechanically weak rock unit there, which has been eroded by the last glacial episode.

Regolithic material is believed present at sample sites 24-4 and 24-5. This material has apparently formed from fluvial material (the Nonacho Series, Henderson, 1937) during the depositional history of the Nonacho Series.

No polymetamorphic rocks are present along Profile Six. Aerial photographs show a prominent lineation west of the small lake which marks the western end of this profile. This feature may correspond to the retrograde/reworked contact described in the discussion of Profile Four. This would mean that the postulated southern gneissic dome has upper amphibolite-facies gneisses on its east flank, as well as on the west side (Profile Three).

4.8 Profile Seven

4.8.1 Location

Profile Seven crosses a bay on the north shore of the southern portion of Lake 4 (Figure 12). It consists of three samples collected about five hundred feet apart in the pre-Nonacho Series gneisses (Map Unit 4, Map 1) and three samples spaced similarly in the Nonacho Series (Map Unit 5, Map 1). The two sets of samples are separated by a bay, which obscures the actual pre-Nonacho gneiss-Nonacho Series contact; the total length of the Profile is about 3/4 mile.

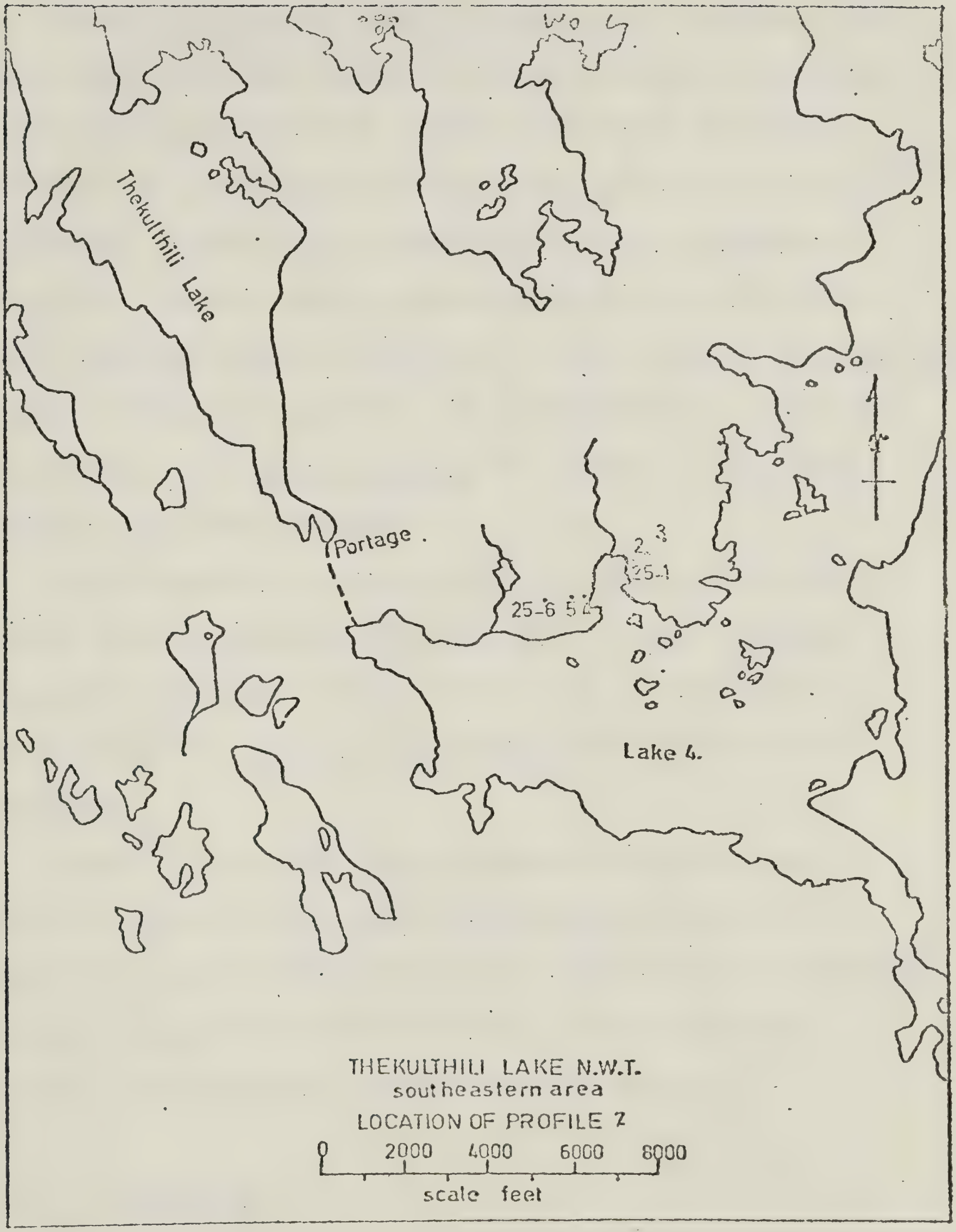

Thekulthili Lake
Portage
3
2
25-1
25-6
5
4
Lake 4.
THEKULTHILI LAKE N.W.T.
southeastern area
LOCATION OF PROFILE 7
0
2000
4000
6000
8000
scale feet

Figure 12.

4.8.2 Observations

Samples 25-1, 2 and 3 are described in Table VIII as altered leucocratic granite gneisses. Feldspars are quite sericitic and the quartz grains present in these samples are streaked and rodded. Hematite staining pervades rod-like zones in the rock, believed to be an expression of destroyed pre-existing ferro-magnesian minerals. These samples generally show the effects of a weak metamorphic alteration on a pre-existing amphibolite-facies (or higher) gneiss. No undisputable evidence of polymetamorphism *sensu stricto* is present in the thin sections of these samples.

Trace amounts of chlorite are present in Nonacho Series (Map 2) samples 25-4 and 25-5. This indicates diagenetic processes only, within the contact zone of the Nonacho Series and the altered gneiss previously described.

Sample 25-6 shows no metamorphic minerals and is therefore essentially unmetamorphosed Nonacho Series sericitic cobble-sandstone. This sample site is farthest from the assumed contact with the altered gneissic complex, which occurs somewhere under the bay.

4.8.3 Discussion

A zone of low-grade alteration is apparent along the contact between the pre-Nonacho gneissic rocks (Map Unit 1) and the Nonacho Series (Map Unit 5, Map 1). This

TABLE VIII

Petrographic Description of Profile Seven

	Metamorphic Minerals							Sample Number	Thin Section Description (abbrev.)	Map Unit:	
	sericite	muscovite	epidote/zoisite	chlorite	biotite	hornblende	microcline			Map 1	Map 2
EAST							•	25-3	altered leuco. granite gneiss	BASEMENT GRANITE	1a
							•	25-2	altered leuco. granite gneiss		
							•	25-1	altered leuco. granite gneiss		
	•			•				25-4	sericitic hematitic arkosic meta-sandstone	NONACHO SERIES	5
	•			•				25-5	sericitic hematitic meta-sandstone		
WEST	•							25-6	sericitic gneiss-cobble sandstone		

Thesis Map Units: (Map 2)

7. Intrusive Microcline Granite
6. Mylonite
5. Nonacho Series Cobble-Arkose;
   5a. Meta-Nonacho.
4. Basic or Metabasic Rock
3. Retrograded Biotite Gneiss
2. Polymetamorphic and Reworked Gneisses
1. Basement Granite Gneiss;
   1a. (altered).

alteration has created the mineral chlorite and has caused the partial destruction by hydration and sericitization of pre-existing high-grade minerals. Also, kinematic deformation in the mechanically brittle altered gneiss has taken place. It appears that this low-grade, water-rich alteration has occurred along the non-conformity between the Nonacho Series and the underlying basement gneisses. This alteration did not extend as far as sample site 25-6 but has pervaded the basement gneisses at least as far as sample site 25-3 (Figure 12).

Samples 25-4, 5 and 6 are Nonacho Series sedimentary rocks because no regional metamorphic mineralogy is present; samples 25-1, 2 and 3 are classed as altered basement gneisses (Table VIII).

4.9 Summary of Detailed Petrologic Profiles

A compilation of thin section and field data considered along each profile gives an overall view of the geological field relations and map units present in the southern portion of the thesis area. Profiles 1 to 7 demonstrate the field relations and metamorphic gradients present within the Nonacho Series and Tazin Equivalent units (Map 1) and the intrusive gneiss/gneissic dome/altered basement gneiss crystalline rocks which are in contact with those units.

4.9.1 Western Area: Granite Gneiss Intrusion

Profiles One, Two and Three (Figures 6, 7 and 8) all terminate to the west in a very coarse-grained microcline granite intrusive body which has influenced many of the field relations observed here. Hornfelsic rocks (samples 19-11 and 20-23) abut this intrusion, pegmatitic veins (Profile One) and granite veins (Profile Three) cut neighbouring rock types. A thermal gradient decreasing away from the intrusion (Map Unit 9, Map 1) is noted (Profiles One and Two). The heat source appears to have caused retrogressive metamorphism of those portions of the pre-existing amphibolite-facies gneisses and cataclasites which now possess hornfelsic or greenschist-facies mineral assemblage. These rocks differ from the retrograde gneisses of the southern thermal dome only because of their cataclastic nature. (see Map 2).

4.9.2 Southern Thermal Dome

A polymetamorphic gneissic core appears to be the centre of the thermal aureole shown in Profiles Four, Five and Six. Gneisses containing quartzo-feldspathic lenses resembling relict metamorphic granite clasts are observed above an apparent metamorphosed unconformity. Retrograded gneisses on the flanks and nose of this structure, suggesting that this gneissic dome plunges to the north, under the Nonacho Series. A coalescence on the west

flank of the mantled dome, and the western intrusive granite (Profile Three) indicates that the entire domal structure pre-dates the intrusion.

Any evidence of a transition from gneisses to unmetamorphosed sedimentary rocks at best is tenuous.

4.9.3 Altered Basement Gneiss

Weak alteration of the Nonacho Series and its basement gneiss suggests that this eastern area was either in a thermal "trough" during the intrusion of the granite in the west and the southern mantled gneissic dome, or else was maintained at a higher crustal level. Hydrothermal activity along the contact at the time of the intrusion of the southern dome is likely responsible for the alteration along the non-conformity.

4.9.4 Conclusions

Several conclusions may be drawn from the evidence cited in this chapter. Firstly, the transition between unmetamorphosed sedimentary rocks to medium-grade paragneisses is generally undefined. The Tazin Equivalent (Map Unit 3) may be an older rock unit than the Nonacho Series (Map Unit 5, Map 1). Secondly, the thermal regime in the thesis area decreases into the Nonacho Series basin. The granite on the west shore of Thekulthili Lake intruded by the country rock. The mantled polymetamorphic gneissic dome in the south shows evidence

of doming but in a solid crystalline state and the basement complex to the east is slightly altered.

It may then be deduced that the Nonacho Series, after being deposited in a pre-existing graben, was subjected in part to weak regional metamorphism. Contact metamorphism has occurred with the late-stage intrusion of the microcline granite to the west. Some thermal effects on the Nonacho strata are apparent along Profile Four and Seven, where contacts between the two rock units are more visible. The general geology, as shown in Map 2, is largely deduced from the information given in Profiles One to Seven.

CHAPTER FIVE

REGIONAL GEOLOGIC DATA

5.1 1958 Rock Suite

5.1.1 General Statement

Drs. R.A. Burwash and R.S. Taylor collected the 1958 suite of rocks mainly for purposes of age determination. Their objective at that time was not unlike the purpose of this thesis: to attempt to solve the problem of the age and field relations of the Nonacho Group with its neighbouring granitic rocks. The samples were collected in a more-or-less linear pattern, down the eastern shore of the main portion of the lake. This data is treated mostly as a supplement to the information derived from the 1975 field season profiles, because it was collected in a different manner.

The metamorphic nature of the samples collected, when compared to the lithological units described by Henderson, gives results consistent with those obtained from the 1975 field season data at the south end of the lake.

5.1.2

Metamorphism Along the Eastern Margin of the Nonacho Series

Contact metamorphism is apparent in undeformed Nonacho Series conglomerates in the Salkeld Lake area, adjacent to

Henderson's "intrusive granite" rock unit (Map Unit 1, Map 1). Samples 3635, 3644, 3647, 3650 and 3652 all contain new growths of brown biotite and have hornfelsic textures. (Plate VII and VIIIa-d). These samples are plotted on Figures 30 & 31 as map unit 5a.

This evidence of a post-Nonacho thermal event is compatible with the confirmation of an intrusive granite at Profile One (Section 4.2.3.). However in the Salkeld Lake area, the thermal influence is manifested directly in the Nonacho Series rock rather than by retrogression of a neighbouring gneiss. Chlorite-epidote/zoisite-biotite-plagioclase mineral assemblages within the Nonacho suggests a compatability with greenschist-facies metamorphism.

Evidence of weak or greenschist metamorphism in Nonacho sedimentary rocks are also found further south along the mapped non-conformity with Henderson's "older granite" (see Table IX). As well, rocks designated as basement granites by Henderson often show retrograde metamorphic effects, which indicate greenschist-facies conditions occurring after initial amphibolite-facies formational temperatures. It therefore appears that retrogression of at least those gneisses along the non-conformity to P-T conditions compatible with prograde lower greenschist-facies mineralogy within the Nonacho Series rocks has occurred.

PLATE VII
(Sample 3635): New biotite is present in the matrix beside a detrital plagioclase grain, in this sample of Nonacho Series conglomerate, indicating metamorphism of the unit. (Magnified 64 x).

PLATE VIIIa
(Field photograph): Near the collection site of sample 3647, photo shows primary sedimentary textures and stratified nature of the Nonacho Series conglomerates, which in thin section have hornfelsic textures and contain brown biotite.

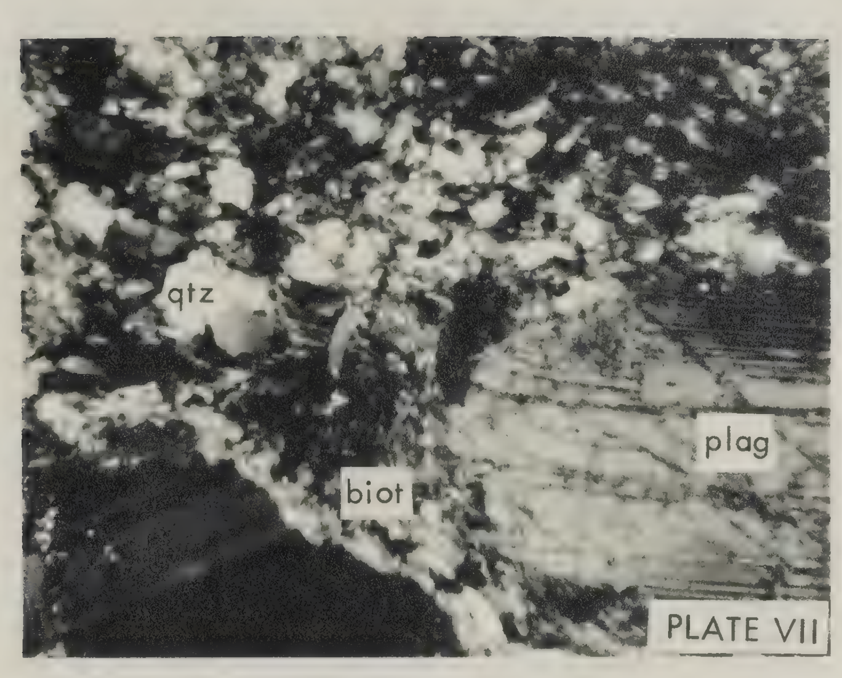


PLATE VII

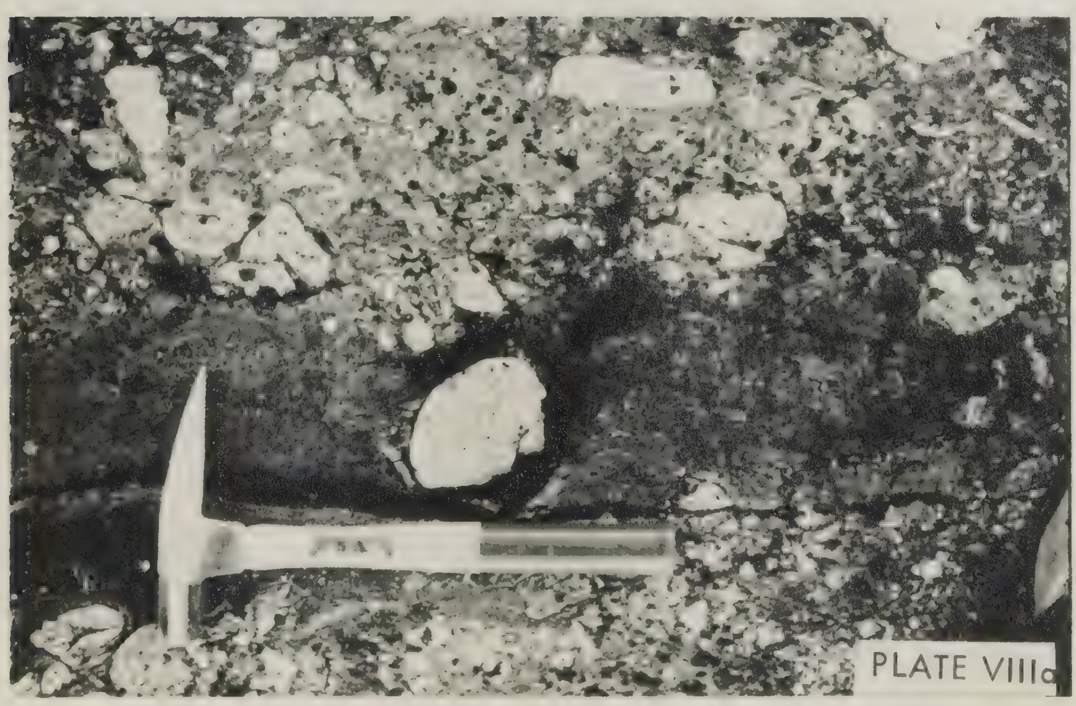


PLATE VIIIa

PLATE VIIIb
(Sample 3647): Photomicrograph shows the contact area of a granite pebble with the matrix minerals in the Nonacho Series conglomerate. (Magnified 6.4 x)

PLATE VIIIc
(Sample 3647): Higher power photo shows new biotite growing at the contact of the granite pebble and the matrix. (Magnified 64x)

PLATE VIIId
(Sample 3647): Granite pebble is in lower half of photo, and consists here of epidote and quartz, while epidote/biotite minerals are present in the matrix, indicative of a metamorphic event affecting the conglomerate. (Magnified 260 x)

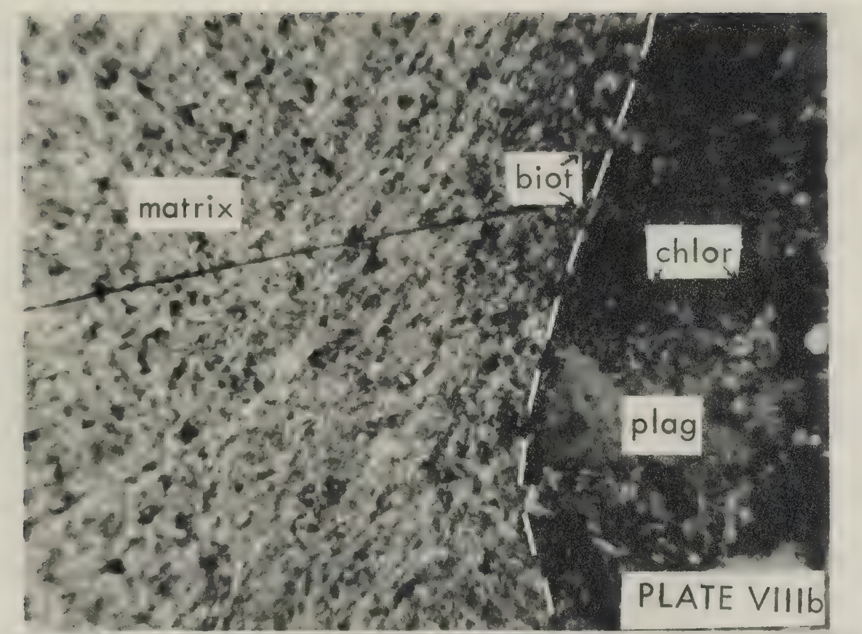


PLATE VIIIb

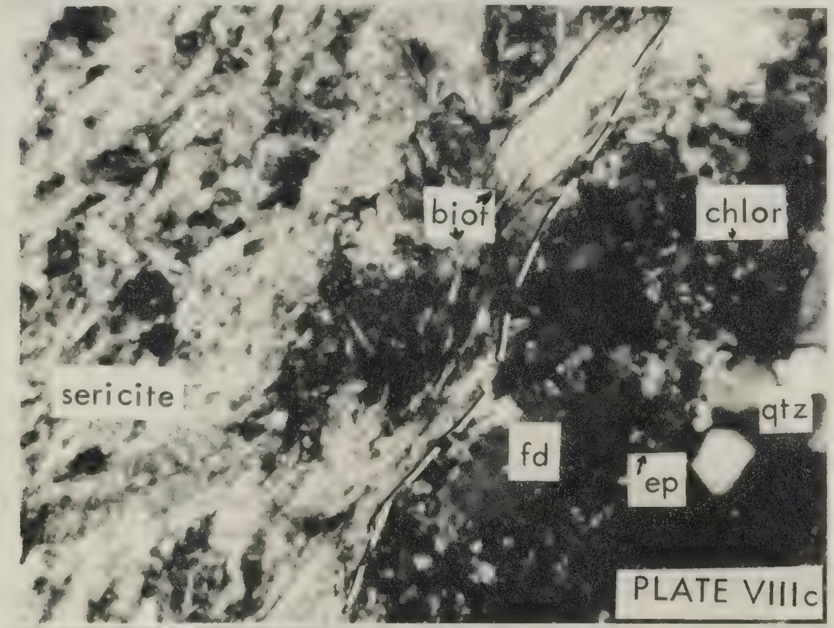


PLATE VIIIc

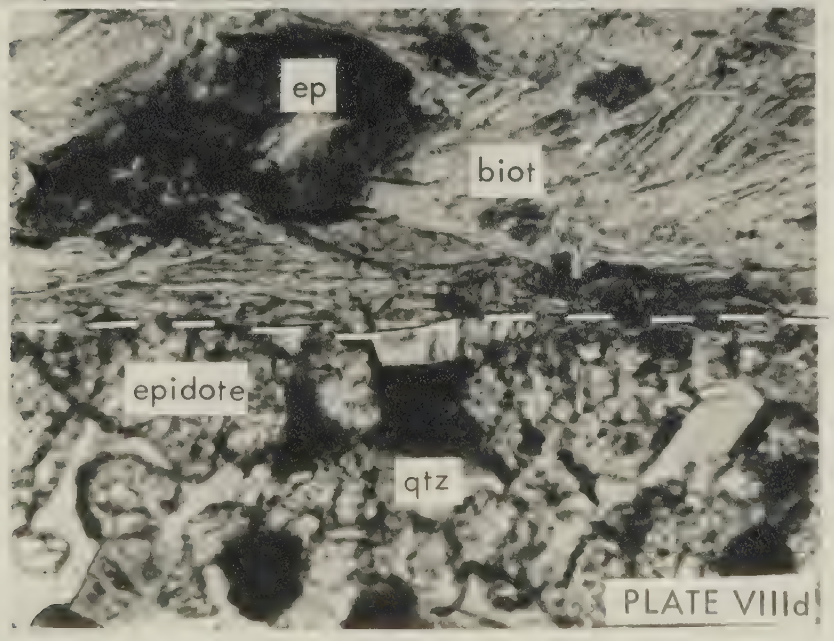


PLATE VIIId

Samples of gneisses farther away from the contact (e.g. Samples 3710-12) are amphibolite-facies rocks.

5.1.3 Summary

The Nonacho Series map units are present along the eastern extent of Thekulthili Lake as both unmetamorphosed (Map Unit 5, Map 2) and weakly thermally metamorphosed or dynamothermally metamorphosed rock units (Map Unit 5a). The metamorphic facies appears to be compatible with the gneissic or granitic "basement" rocks abutting the Nonacho Series map units, which all show evidence of retrograde metamorphic effects to greenschist-facies. Samples away from the contact indicate amphibolite-facies, and the presence of a thermal gradient, with temperature decreasing towards the Nonacho Series units, a similar manner indicated by the 1975 profiles.

Henderson's interpretation of the alternating intrusive-unconformable granite/sedimentary rock contact was likely based upon the aspect of these rocks in the field rather than on their petrology. Uniform retrogressive metamorphism of the basement tends to combine the granites designated as units 4 and 9 on Map 1, into one reactivated basement gneiss unit, designated as units 1, 2 and 3 on Map 2. This suggests that the present-day erosional surface cuts through a section of Hudsonian and pre-Hudsonian rocks, beginning in unmetamorphosed Nonacho Series cobble-arkoses, crossing a weakly metamorphosed

nonconformity, and continuing into a polymetamorphic gneissic complex of a deeper crustal cut. This differs from the interpretation of the 1975 Profile Four area in that the higher grade gneisses may not be confined to a domal structure.

The 1958 rock suite data discussed here was designed to supplement the 1975 field season rock suite and add regional control to the area of study. This earlier collection of rocks from Thekulthili Lake also show that the basal portion of the Nonacho sedimentary rock units have indeed been subjected to a regional metamorphic episode. Survival values of 2240, 2260 and 2420 million years (Burwash and Baadsgaard, 1962) give independent evidence indicating Kenoran age origins of the basement gneisses. Younger 1790, 1800 and 1850 million year dates (Burwash and Baadsgaard, 1962) show a complete up-dating of the K/Ar "radiometric clocks" to Hudsonian time in some gneisses. Figure 34 (Chapter Nine) shows the location of these as well as G.S.C. age determinations.

Appendix #I gives a description of the rocks listed in Table #IX and found on Map #2, giving their diagnostic metamorphic mineral assemblages.

TABLE IX

1958 Rock Suite Grouped According to Metamorphic Facies

Unmetamorphosed Sedimentary Rocks	Greenschist-Facies (*denotes basement) (+denotes contact metamorphism)		Amphibolite-Facies Metamorphic Rocks (*denotes basement)	Basement Rocks* (Metamorphic facies not indicated).
3646	3635+	3674 A,B	3644	*3662
3649	3636	3676	3648	*3673
3731	3637	*3677	3652	*3711
3734	3638	3678	*3653	*3712 A,B
3736	3639	*3679	3654	*3735
	3640	*3680	*3655	*3738
	3644+	*3690	3659	
	3645 A,B	3691	3663	
	3647+	*3692	*3664	(basic rocks)
	3650+	3693 A,B	*3666	
	3651	3695	*3710	
	3652+	*3696		
	3657	3699		3669
	3658	*3706		3670
	*3660	*3708		3704
	*3661	*3709		3705
	3665 A,B	3716		3718
	*3667	3717		
	3671	3719		
	*3672	3720		
		3725		
		3732		
		3737		
		3740		

5.2 Structure

McGlynn (1967) has shown that the Nonacho Series strata are preserved in what appears to be a demi-graben basin, which is faulted to depth in the west and has the original nonconformity preserved in the east. The axes of a series of compressional folds across the basin trend subparallel to the length of the rock unit. Local structural data collected during the 1975 field season are presented here in the context of McGlynn's general interpretation, and with respect to the field relation of the Nonacho to adjacent rock units.

Figure 13 is a structural map showing bedding and foliation orientation data, which was collected in the field during the 1975 field season. The information derived from this data supplements the field relations between the Nonacho Series at its southernmost abrupt termination, with the adjacent granitic or gneissic lithologies. Comparisons between the orientation of the Nonacho and the foliation of the gneisses is best shown along Profile Six (see Figure 11) but possible everywhere to some extent. Clearly, any relict bedding or penetrative deformation reflected in the present-day orientation of the gneisses has little or no correlation to the strike of the folded Nonacho strata.

Within the Nonacho Series, the bedding strikes differed considerably in orientation from Profile to Profile

but are reasonably constant along any one Profile. Dip measurements were difficult to take due to the massive nature of the sandstones and conglomerates.

The gneisses which border the Nonacho to the south (discussed in Chapter 4) are shown to have an eastern and western flank. The foliation is subparallel to the northeasterly trending Hudsonian orogenic fabric and also aligns with the strike of Thekulthili Lake. The slight change in strike between the polymetamorphic core and the nearby retrograde gneisses on Profile Four is graphically evident. (See Section 4.5.3). As well, the reversal of dip at the western edge of the mantled gneissic dome is (Section 4.4.2) shown.

Thekulthili Lake appears to occupy a major structural break between the gneisses and granites and the Nonacho Series. (See Figures 14 and 15). Several movements along the west edge of the Nonacho Series basin are reflected in the cataclastic textures of sample 20-21. Several generations of crush material are evident in this specimen. The west bay fault which is crossed by Profiles One and Two was likely activated several times. Mylonite clasts present within the Nonacho sedimentary rocks are evidence of pre-Nonacho movements; crushing of mylonite or cataclastic rock may be related to a post-Nonacho movement, during a later period of orogenic activity (which likely caused the infolding of the Nonacho strata).

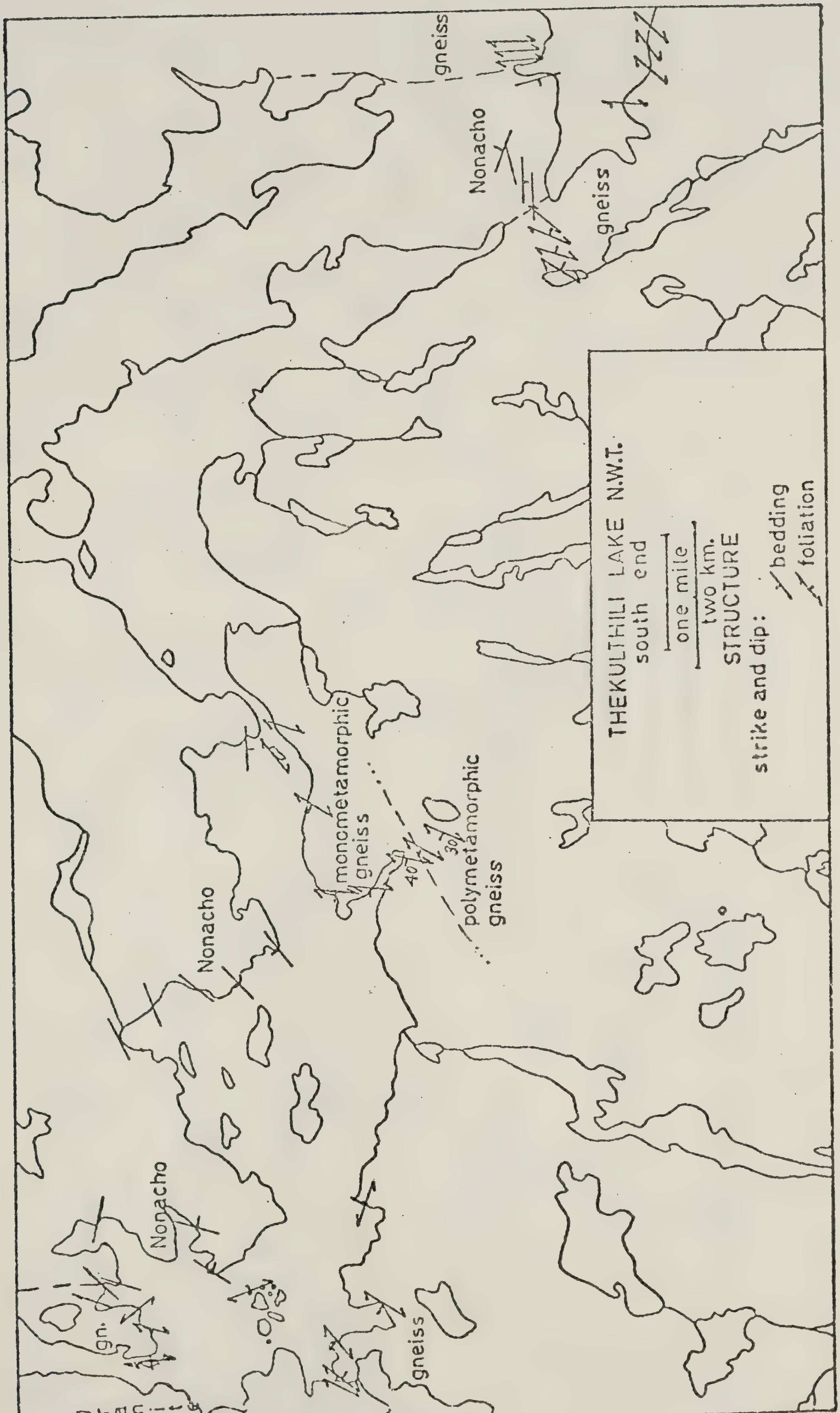

THEKULTHILI LAKE N.W.T.
south end
one mile
two km.
STRUCTURE
strike and dip:
bedding
foliation
gneiss
Nonacho
gneiss
monometamorphic gneiss
polymetamorphic gneiss
40
30
Nonacho
Nonacho
gn.
granite
gneiss

FIGURE 13.

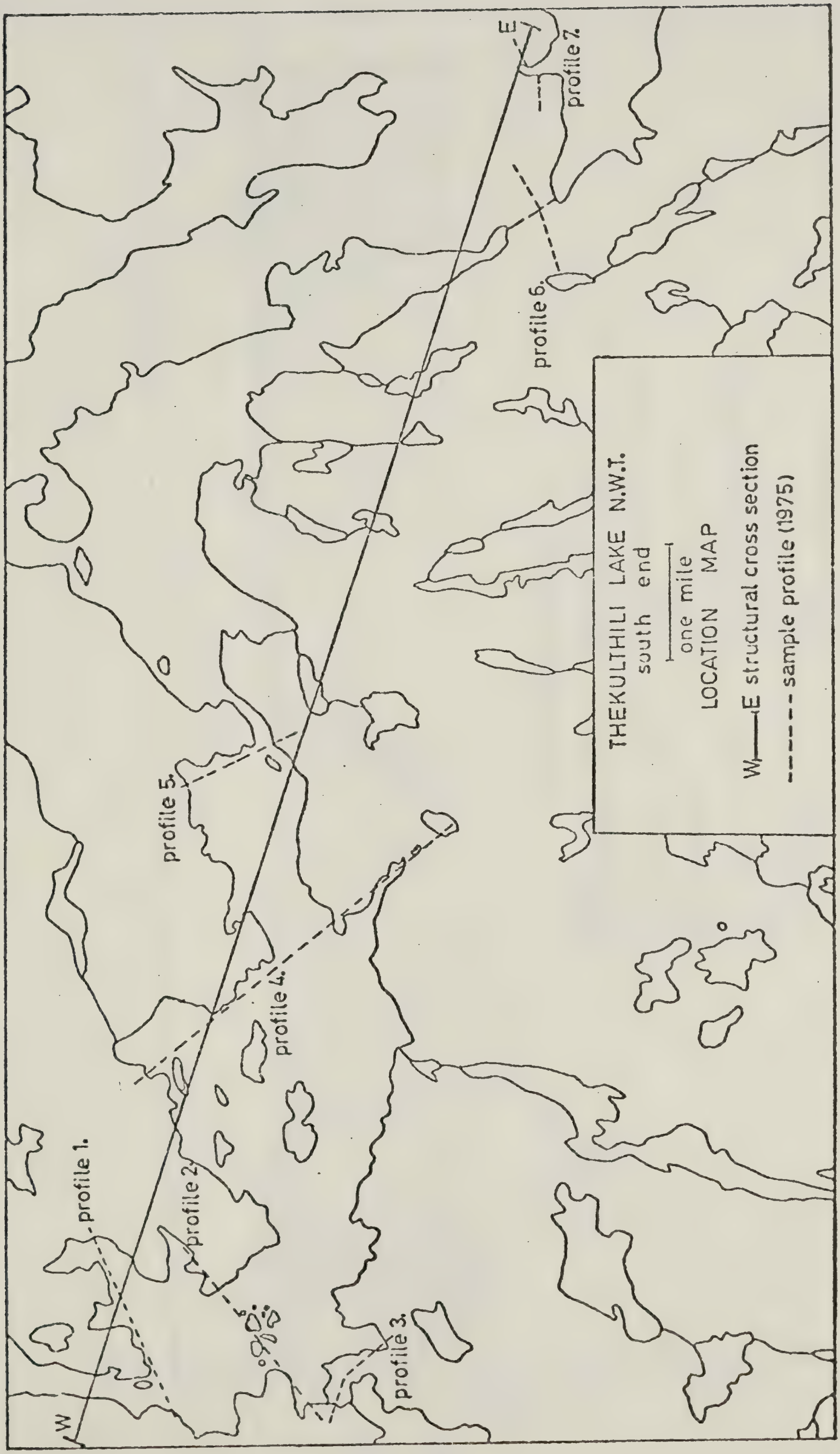

THEKULTHILI LAKE N.W.T.
south end
one mile
LOCATION MAP
W——E structural cross section
------ sample profile (1975)
profile 1.
profile 2.
profile 3.
profile 4.
profile 5.
profile 6.
profile 7.
W
E

Figure 14.

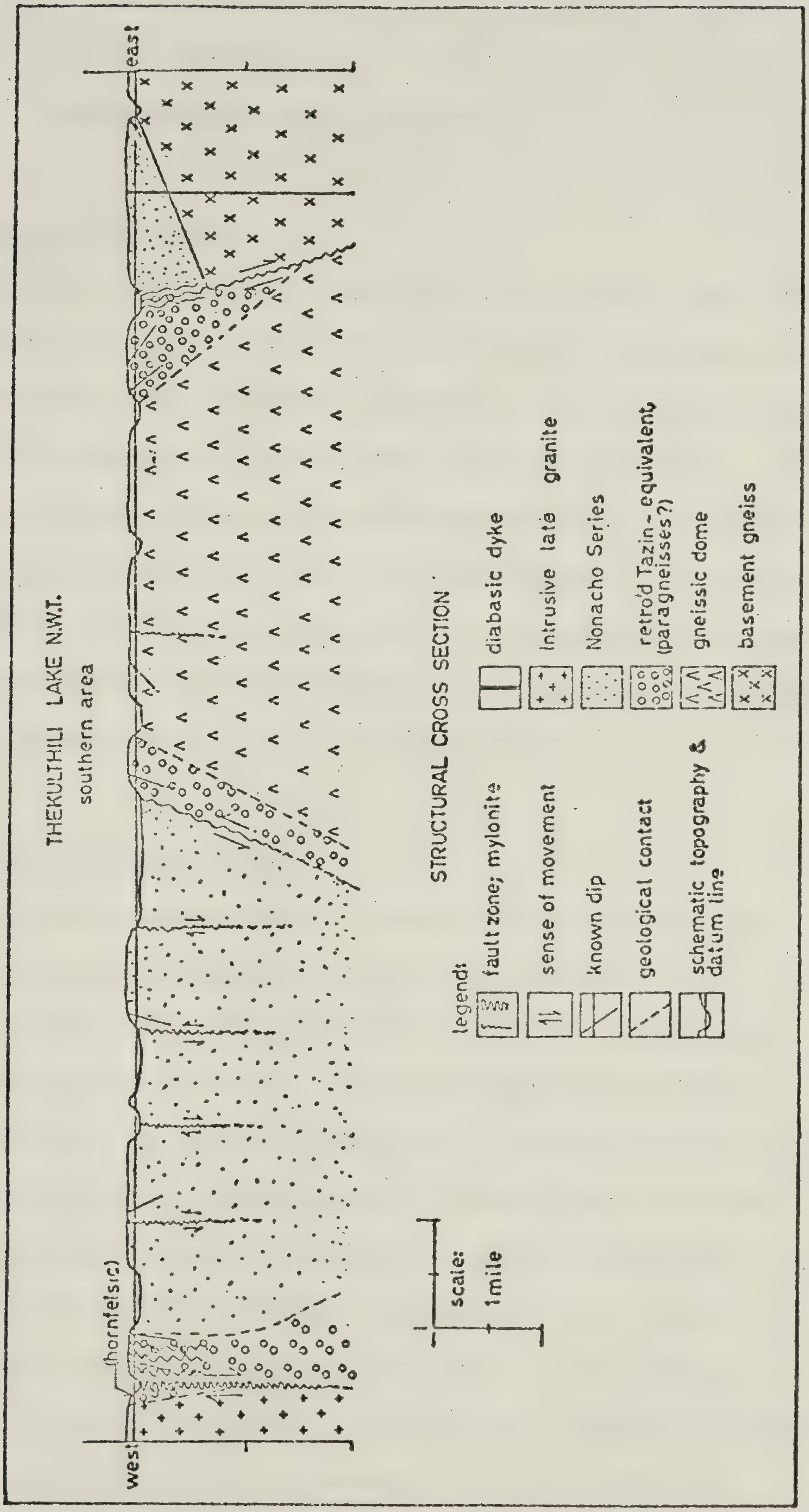

THEKULTHILI LAKE N.W.T.
southern area
STRUCTURAL CROSS SECTION
west
east
(hornfelsic)
scale:
1mile
legend:
fault zone; mylonite
sense of movement
known dip
geological contact
schematic topography & datum line
diabasic dyke
intrusive late granite
Nonacho Series
retro'd Tazin-equivalent, (paragneisses?)
gneissic dome
basement gneiss

Figure 15.

CHAPTER SIX

AEROMAGNETIC OBSERVATIONS

6.1 General Statement

Airborne aeromagnetic surveys of this area were flown for the Geological Survey of Canada during the years of 1960 and 1962. The published maps were not corrected for regional variation in the Earth's geomagnetic field. The results of these surveys have been published on scales of one inch equals one mile, and one inch equals four miles. A comparison of the maps compiled on a scale of one inch equals four miles with the geology of the same area gives a better understanding of the thesis area.

6.2 Regional Observations

One minor and two major trends are present on the 250,000:1 scale aeromagnetic maps covering the Fort Smith, Taltson Lake, Nonacho Lake and Hill Island Lake areas. Strong north-south tectonic fabrics up to the Macdonald Fault by Great Slave Lake are reminiscent of the Kenoran tectonic fabric found farther north in the Slave Province. Probable meta-sedimentary rock units in the eastern two map sheets, change strike in the vicinity of Thekulthili Lake and orient themselves in a northeast-southwest manner, parallel to the general tectonic fabric of the younger Churchill Province. The two fabrics

converge in the area immediately west of Thekulthili Lake, near the intrusive microcline granite, which is expressed as a strong magnetic high. A zone of overlapping of the two major tectonic fabrics, lies just west of the 110th meridian west longitude. Minor trends in aeromagnetic highs can be found in the study area striking to the northwest. These represent diabase dykes of the Mackenzie Swarm which cut through the area. Larger northwest-trending aeromagnetic highs are also present southwest of Thekulthili Lake. These may represent infolds of meta-sedimentary rocks.

It is believed that the north-south fabric is due to persistent relict Kenoran structural fabric. The north-east tectonic fabric is an expression of folding and metamorphism related to the Churchill orogenic event.

6.3 Local Observations

The most striking feature aeromagnetically which occurs in the thesis area is the pronounced aeromagnetic "dome" in the southwest corner of Thekulthili Lake. This lies over the unit mapped as intrusive microcline granite. It is postulated that magnetite grains within the intrusive body are responsible for the high.

A strong linear high can be found cutting to the northwest from the southeast corner of Thkulthili Lake.

Several more such linear aeromagnetic expressions are present west of the northern portion of the lake. Aerial photographs also show these linear features, identified as larger diabasic dykes cross-cutting the sedimentary rocks and metamorphic rocks in the area. Ground observations at the site of 1958 sample nos. 3680 to 3690, a diabasic dyke, verify the existence of these dykes and their expression on the aeromagnetic maps.

Thekulthili Lake shows up as a slight "trough" on the aeromagnetic maps. This would be due to the topographic depression, which is occupied by the lake, giving increased clearance from the aircraft to bedrock.

With the exception of the aforementioned examples, the entire area of basement granites or paragneisses, and sedimentary rocks, is a relatively low relief, aeromagnetic "plain", with few highs present. Little difference is apparent between the sedimentary rocks and the gneisses in the southern portion of the thesis area.

CHAPTER SEVEN

ANALYSIS OF PETROLOGIC DATA

7.1 General Statement

The mineralogical composition of thin sections examined (Appendix I) has been treated statistically, as well as petrogenetically. The population of each grouping of rocks varied from 3 to 58, limiting the quantitative certainty of some groups; nevertheless, the results from thin section study data shown here appear consistent with petrogenetic and field relation conclusions discussed in Chapter Four.

7.2.1 Formation of Rock Units

Mapping was not a prime objective of this study; however the designation of rock units for purposes of discussing the field relations of the Nonacho Series was necessary. Thin section descriptions gave the basis on which the units were delineated: primary criteria were the lithological and genetic relationship of each rock type with all others in the area. The metamorphic facies of the sample was a secondary basis of division among similar lithologies, e.g. the basement gneiss. The classical petrographical descriptive method employed by Moorhouse (1959) was believed to be too fine a division to make

for purposes of studying age relations. A petrogenetic name, with due consideration given to the sample's field location, yielded eight major divisions (with one significant subdivision in one unit):

8. Diabase
7. Intrusive granite
6. Mylonite
5. Nonacho Series
5a. Hornfelsic Nonacho Series
4. Basic rocks
3. Retrograded gneiss
2. Polymetamorphic (Reworked) gneisses
1. Eastern basement gneisses

7.2.2 Mineralogical Composition Analysis

The mineralogical composition of major rock groups, as determined by modal analysis (Volume percent) was plotted on triangular diagrams. The number of sample points plotted in a 10% triangular area was contoured for both quartz-total feldspar-total mafic minerals as well as quartz-plagioclase-K-feldspar percentages. Patterns of composition in each rock group, and between related rock units are discussed here.

Unit 1: Eastern Basement Gneisses:

Figures 16 & 17 represent those samples collected in the 1958 field season, from the basement rocks.

The felsic minerals diagram shows a mid-range concentration with a decided skew towards a second population in the granodiorite (plagioclase abundant) sector. A weak trend towards the granitic side of the triangle persists. These samples may then be considered as generally quartz monzonitic or granodioritic gneisses.

A plot of mafic minerals versus felsics (total feldspar and quartz) gives a heavy concentration of points on the leucocratic side of the diagram. A tight cluster is evident in the 20 to 60 percent quartz range (relative to total feldspar) with only a slight scatter towards the mafic end member. Most of these gneisses have less than 10% mafic minerals present, and are more feldspathic than quartz-rich.

In as much as the 1958 rock suite was collected for purposes of radiometric dating rather than for mapping, no further division of the basement gneisses is made. It is believed that these rocks, predominantly amphibolite-facies gneisses, represent an average basement-rock composition for the thesis area.

Unit II: Polymetamorphic (Reworked) Gneisses:

Deformed, and in part porphyroblastic gneisses present south of Thekulthili Lake contain textural and mineralogical features which indicate that this area has a polymetamorphic history. Those samples collected give a scatter of points when plotted. The population is rela-

tively small. The identified polymetamorphic gneisses have a similar distribution to the eastern basement gneisses (Unit I), as shown in Figures 18 & 19. Generally, plotting granodioritic some scatter, these rocks are mainly leucocratic and lie in the 20-50% quartz versus total feldspar which is directly correlative to Unit I.

The spread of isolated samples on both Figures 18 & 19 show the inhomogeneity of this small population. Nevertheless a trend is apparent, especially upon comparison with other basement rock types.

Unit III: Retrograde Monometamorphic Gneisses:

These gneisses are found wrapping around the polymetamorphic core of the southern thermal dome, south of Thekulthili Lake. Strong trends which are comparable, yet somewhat different, than Unit I are visible in Figures 20 & 21.

Plagioclase is by far in excess of K-feldspar in this rock unit, with a skewed distribution concentrating in the 20 to 50% quartz versus plagioclase area, emphasizing a trend towards granodioritic composition shown in Unit I. A smaller scatter does cross into the quartz monzonitic range of the diagram, representing a compositional spread.

Mafic minerals versus felsic minerals (Figure 21) shows a wide pattern of more uniform density. Grouping along the total feldspar versus quartz side of the triangle is towards the total feldspar end, comparable to

Unit I: Eastern Basement Gneisses (n = 34)

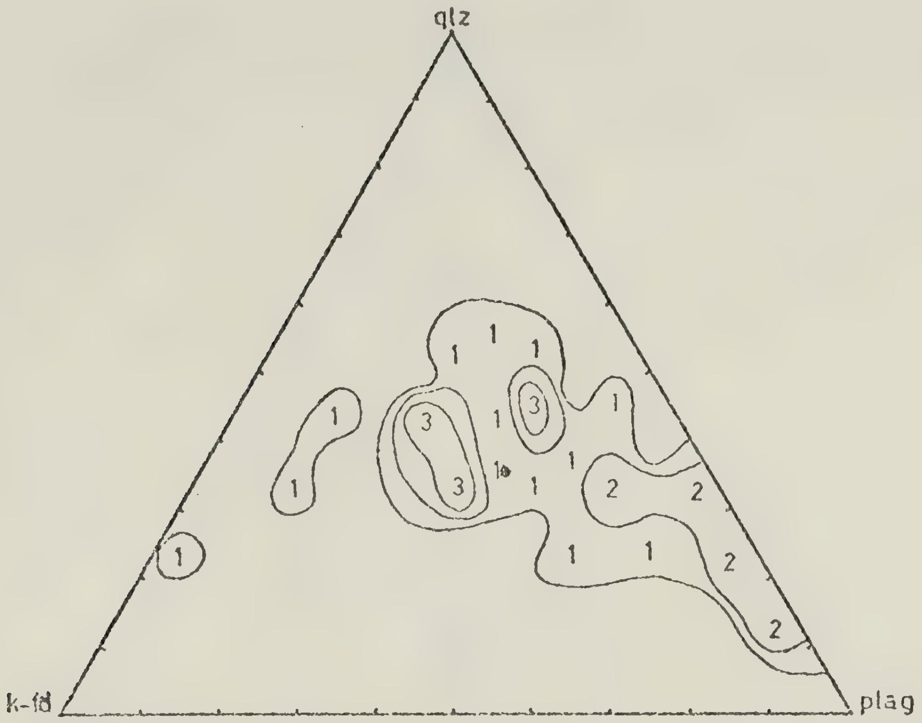


Fig. 16

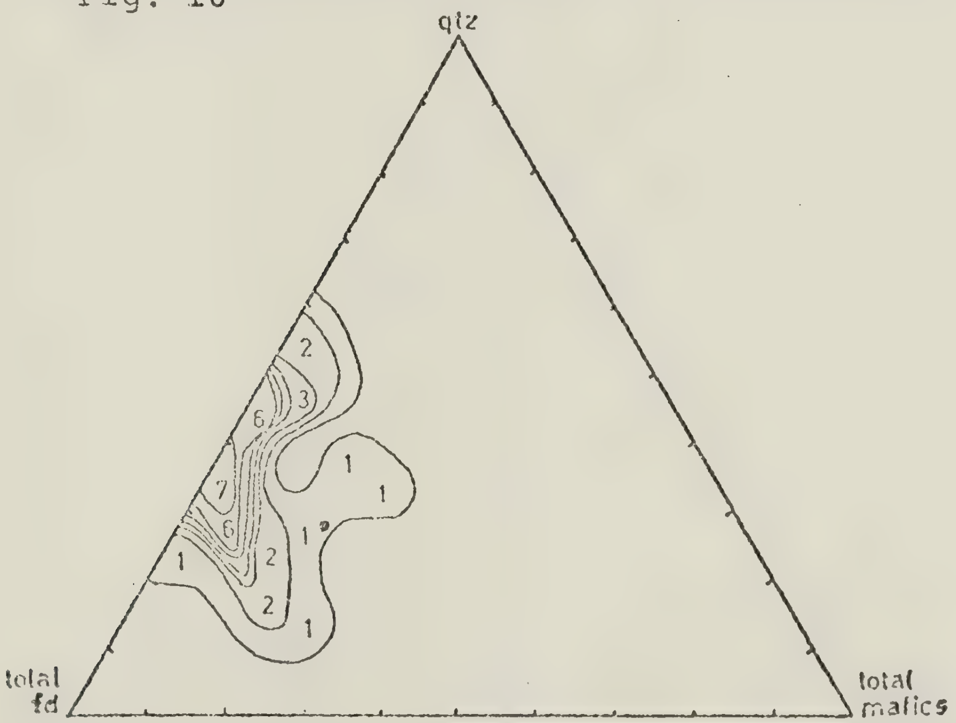


Fig. 17

(• : average basement mineralogy from Burwash and Krupicka, 1969).

Unit II: Polymetamorphic Core Gneisses (n = 9)

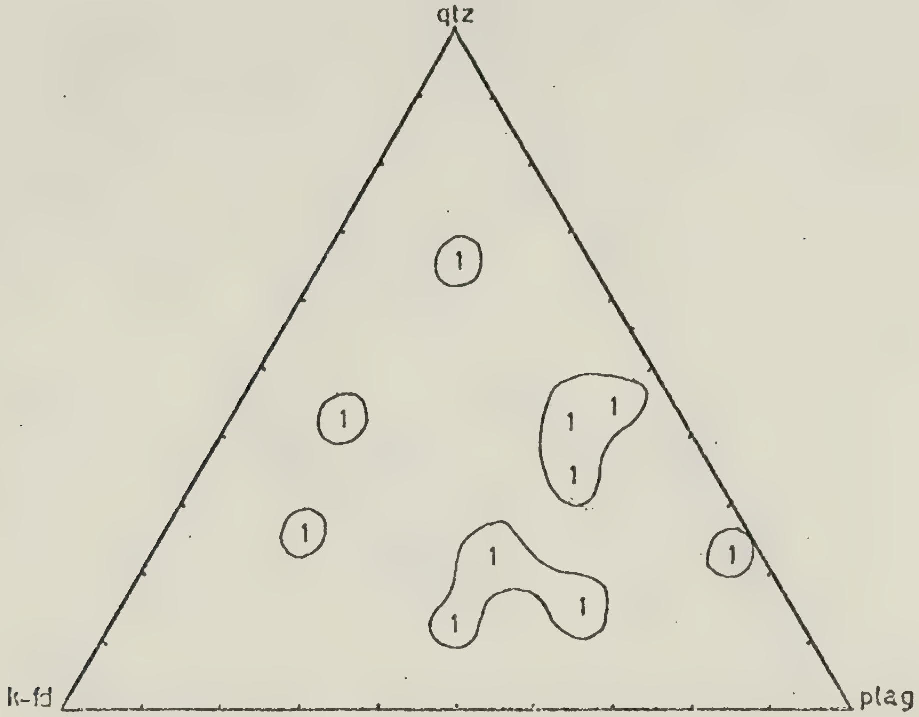


Fig. 18

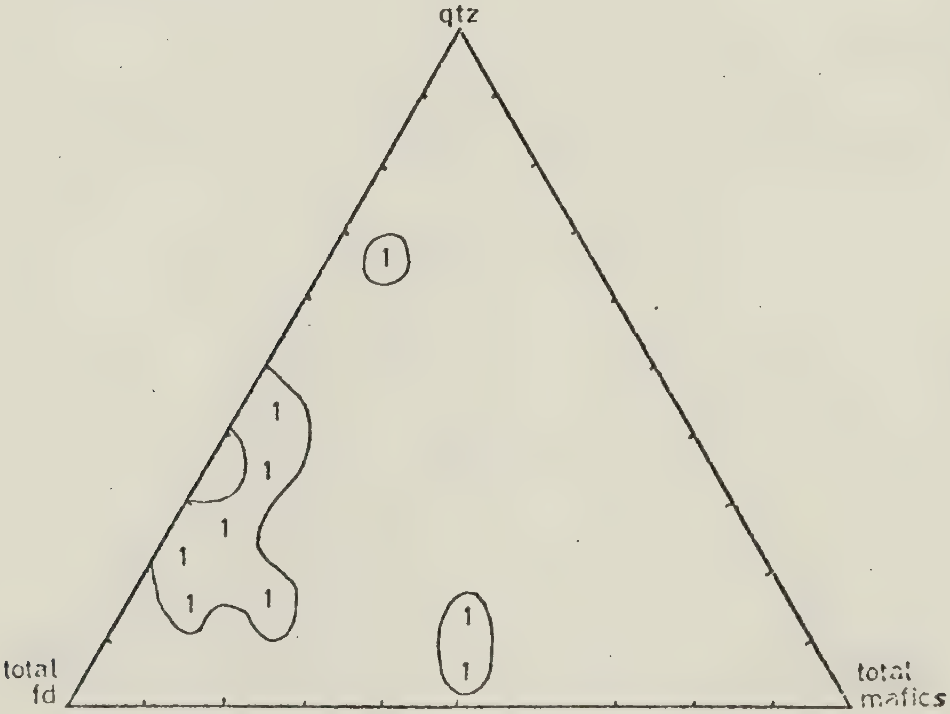


Fig. 19

Unit III: Retrograded Gneisses (n = 35)

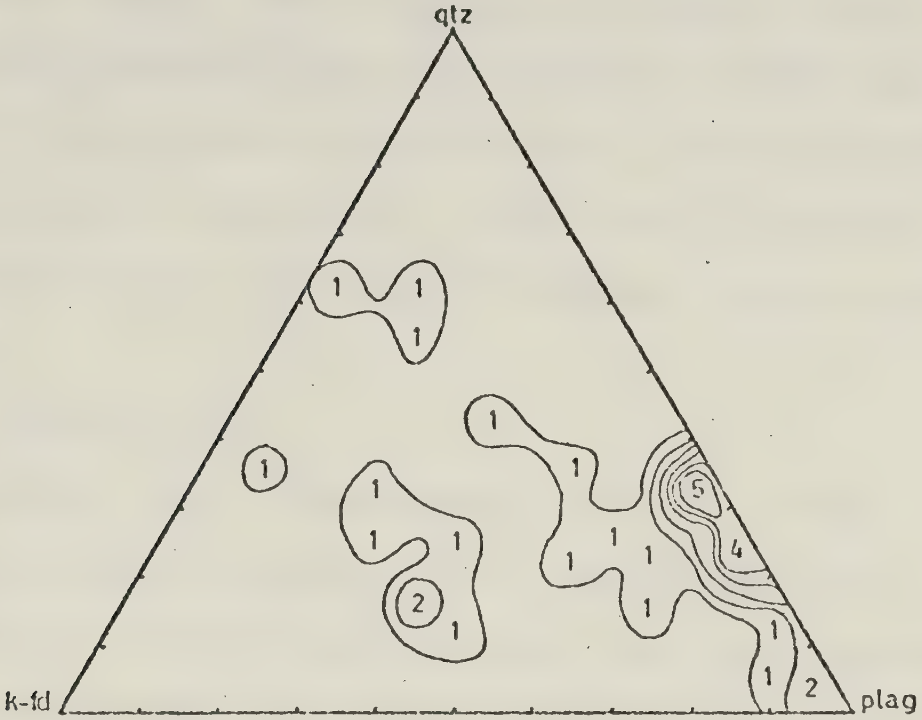


Fig. 20

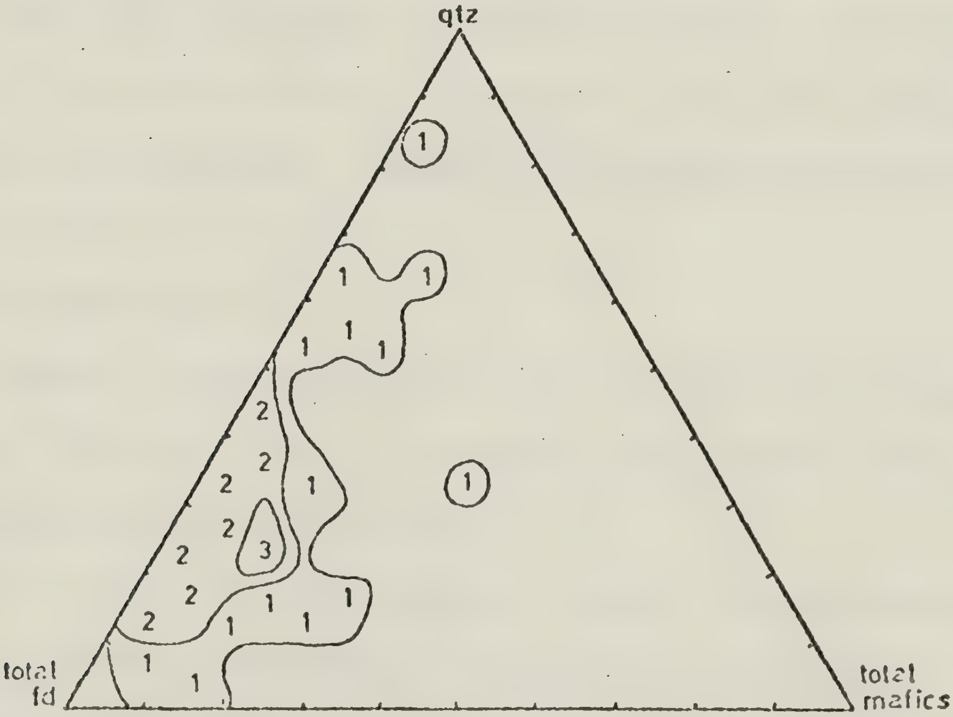


Fig. 21

the eastern basement gneiss, but the leucocratic nature has been lost, with concentration now in the 15 to 25% total mafics range. This reflects the biotite, and epidote-chlorite retrograde mafic mineral assemblages growing at the expense of pre-existing (often preserved as relict grains) amphiboles. This often is directly correlative with the more general basement gneiss rock unit (Unit I).

Unit IV: Basic Rocks:

Figures 22 and 23 demonstrate the mafic, high-plagioclase content of basic rock. These rocks are amphibolites or possibly metadiabase, for the most part. One quartz-rich rock represents a biotitic metasedimentary sample. The mafic content is variable (Figure 23), but lies in the 30 to 80% range. The basic rocks are grouped in a predictable pattern, completely separate from gneissic rocks (Map Units I, II, III).

Unit V: Nonacho Series:

All samples of the Nonacho Series sedimentary rocks are grouped into one unit. A separate population (Unit Va) is derived from this population.

Figure 24 shows a high quartz content, predictable since quartz is an end member in the sedimentary resistate series. A statistical "tail" departs from this K-feldspathic (another more erosionally resistant mineral) and quartz end, and crosses over towards the plagic

Unit IV: Basic Rocks (n = 11)

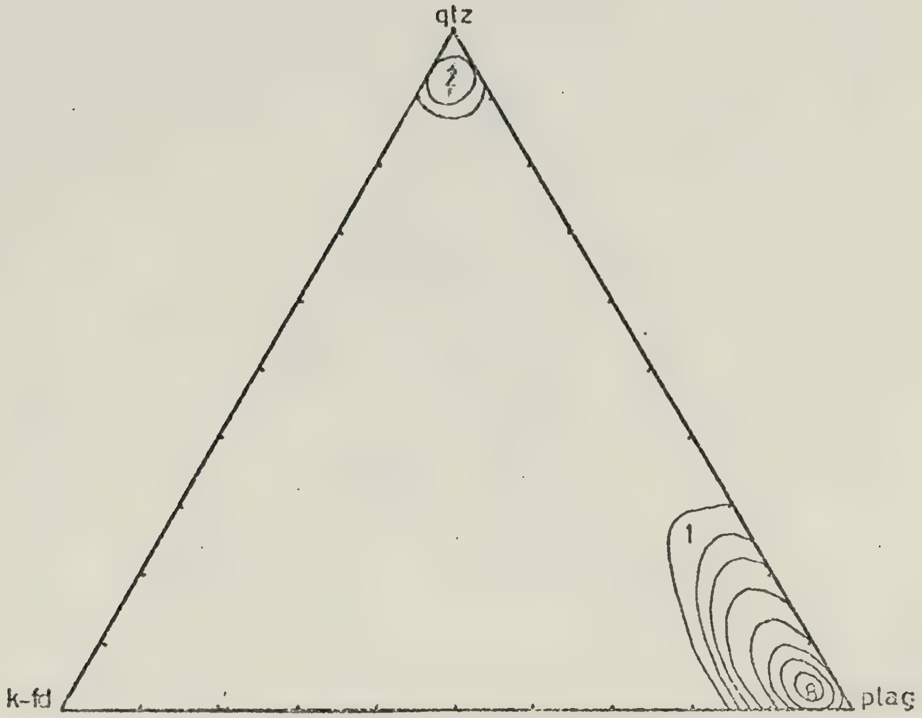


Fig. 22

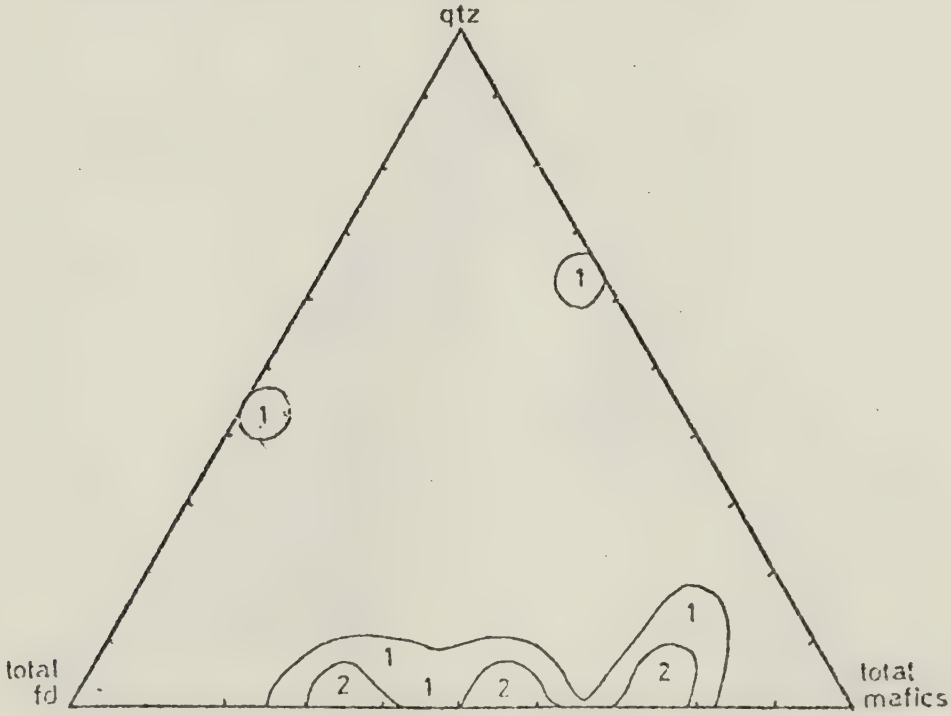


Fig. 23

Unit V: Nonacho Series (n = 58)

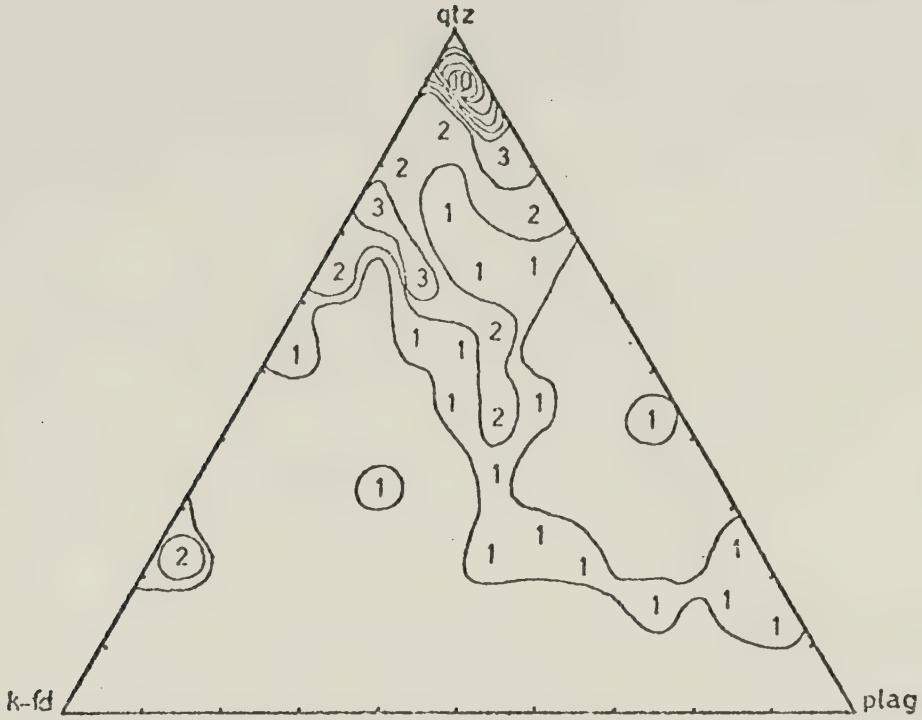


Fig. 24

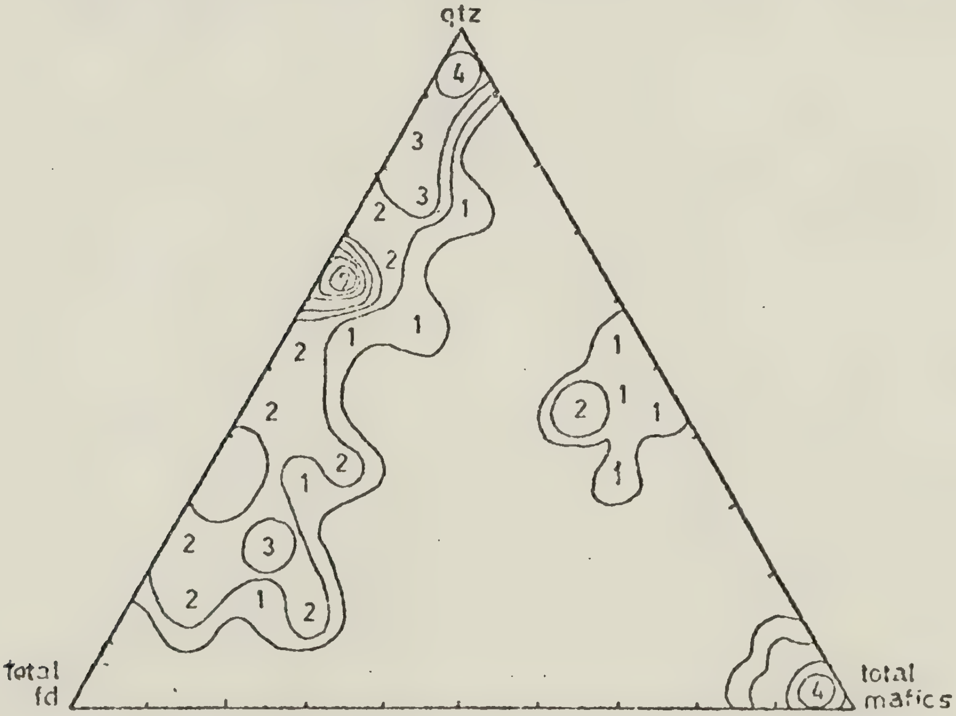


Fig. 25

Unit Va: Thermally Metamorphosed Nonacho Series (n = 5)

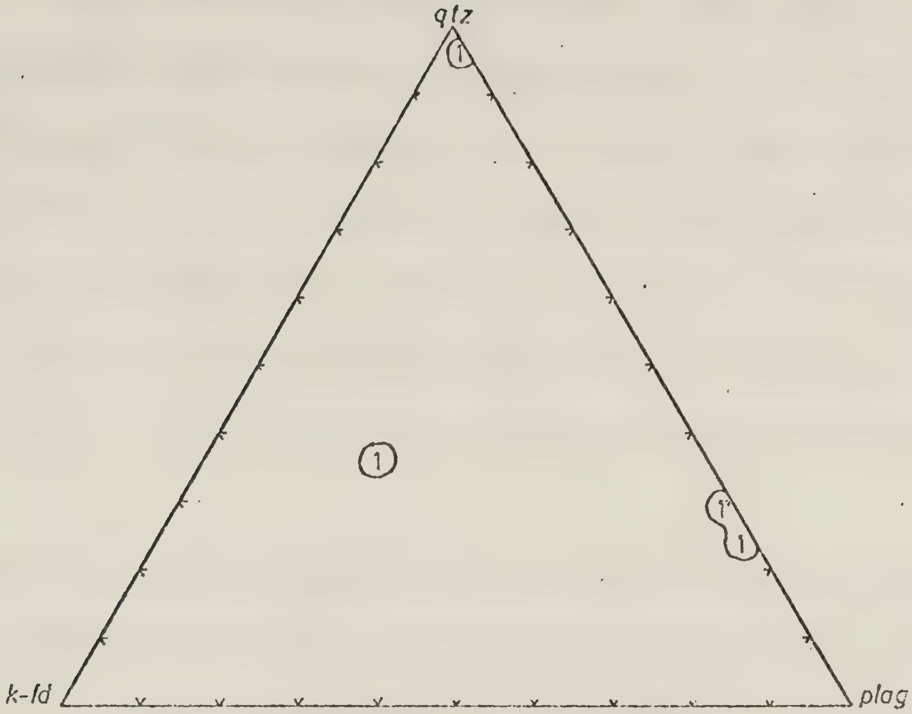


Fig. 26

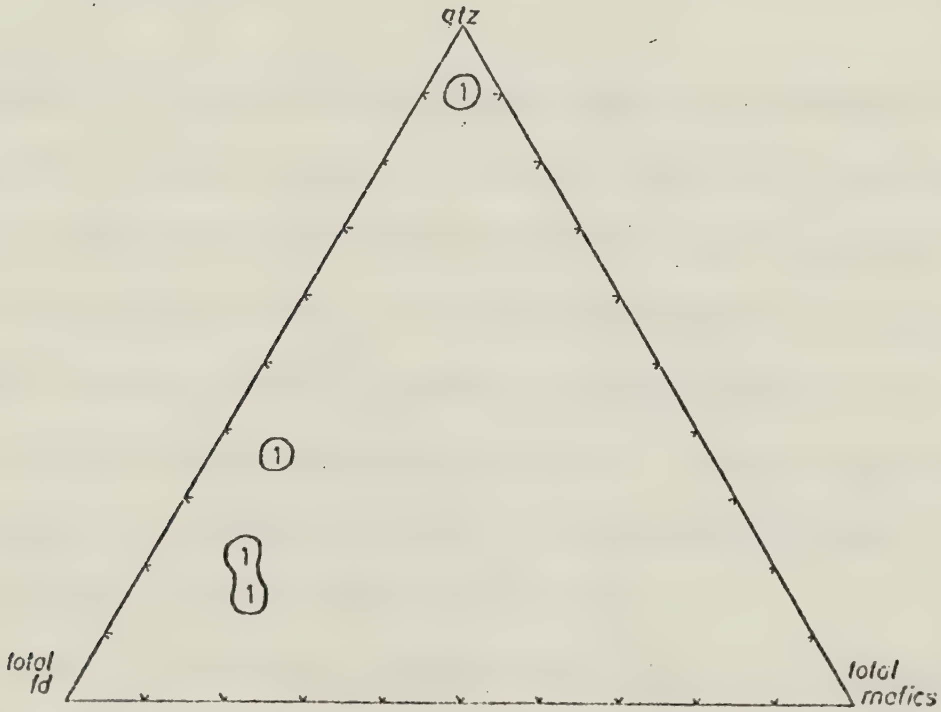


Fig. 27

end. This spread will be discussed under Unit Va.

Figure 25 shows a generally leucocratic nature to the Nonacho Series, likely because mafic minerals are generally less resistant than felsics. The small, high-mafic minerals population is indicative only of the high amount of sericite or white-mica form in the finer-grained rocks of the Nonacho Series, formed from reconstituted clay minerals. Another population, half-way between the quartz and mafic minerals end members, is a reflection of the sericitic nature of many sandstone units.

Generally, the Nonacho Series sedimentary rocks plot as being arkosic or subarkosic sandstones, with an abundance of sericite because of diagenetic processes.

Unit Va:

Figures 26 and 27 show representative samples of four Nonacho Series rocks in which hornfelsic textures and contact-metamorphic brown biotite were discovered. Although the relationship to the Nonacho Series is indisputable because of the excellent preservation of primary sedimentary features and their field relations, the rocks plot correlative with the monometamorphic gneisses (Unit III, figures 20 and 21).

The "tail" present on Figure 24, which is a departure from the bulk of the Nonacho Series samples, is caused partly by the contact metamorphic presence of these samples regenerating plagioclase mineralogy, which

is normally too susceptible to erosion to withstand a sedimentary cycle. The slightly more mafic and feldspathic nature of these samples set them apart from the rest of Unit V. One quartz-rich but hornfelsic sample may be regarded as a link between the resistate series of the sedimentary rocks (Unit V) and the metamorphic aspects of gneisses or hornfels (Unit Va and Unit III).

Unit VI: Mylonite:

Figures 30 and 31 show a high-quartz composition of the ultramylonite encountered along profile one. Too few samples and complete destruction of all but the most resistant mineral present do not allow statistical compositional approach to this very local unit.

Unit VII: Intrusive Granite:

The geologic significance of the very coarse-grained microcline granite present west of Thekulthili Lake necessitates triangular plots of the mineralogical composition (Figures 28 & 29). Two of the three samples plot as a quartz monzonite (Moorhouse, 1959) in composition. One considerably more K-feldspathic sample plots abnormally; it likely is affected by the very coarse-grained nature of the microcline crystals in thin section, rather than a divergence in rock composition. This unit shows poor correlation with the major mineralogical distribution of gneissic Units II and III, although could be considered correlative to the more general Unit I. The

Unit VII: Intrusive Granite (n = 3)

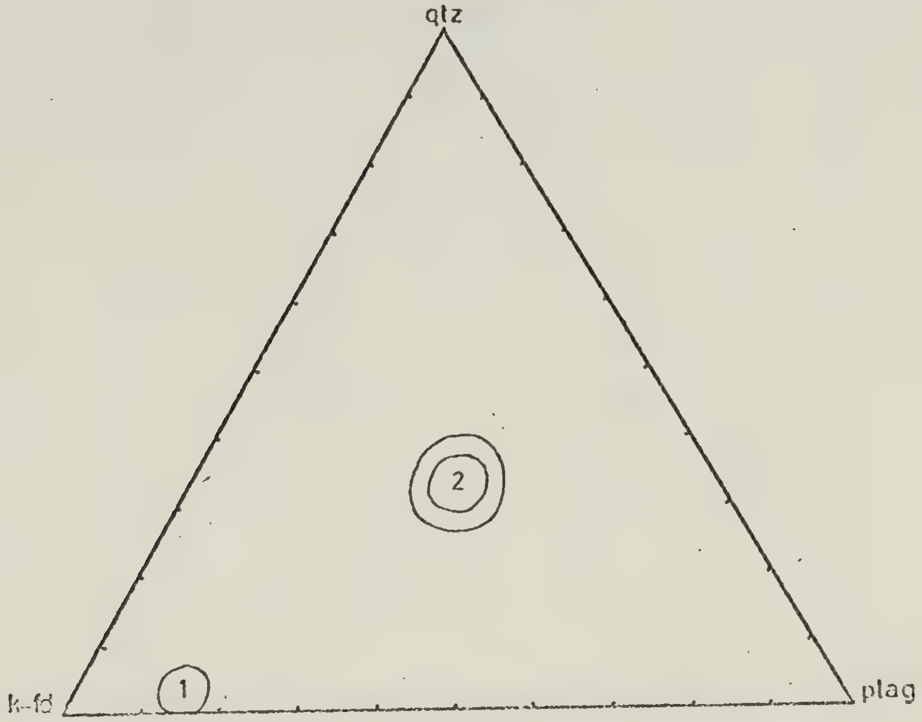


Fig. 28

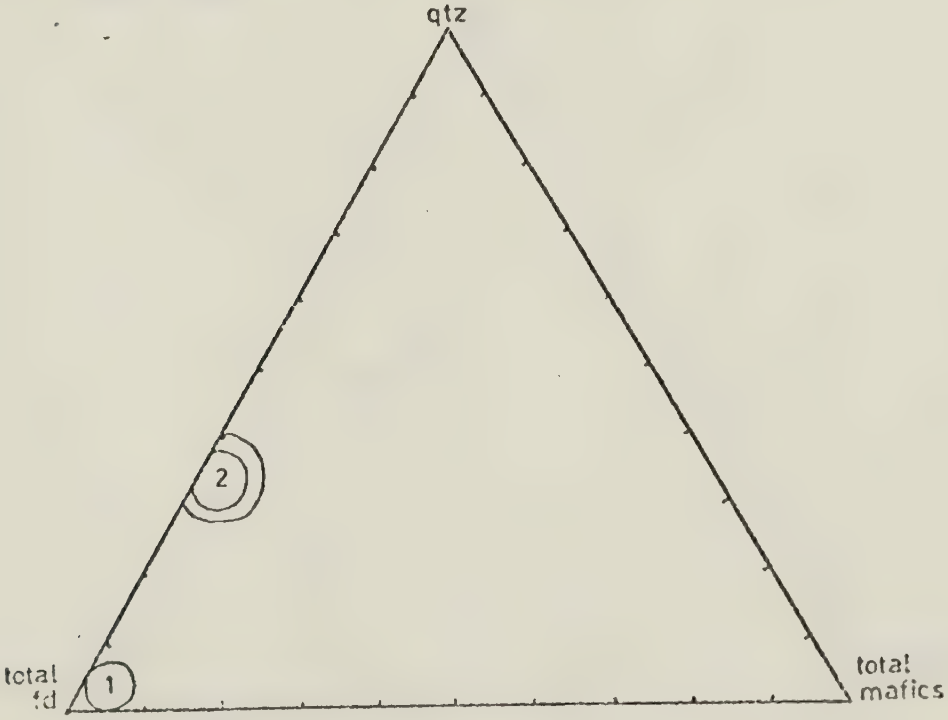


Fig. 29

Average Compositions of Major Rock Units

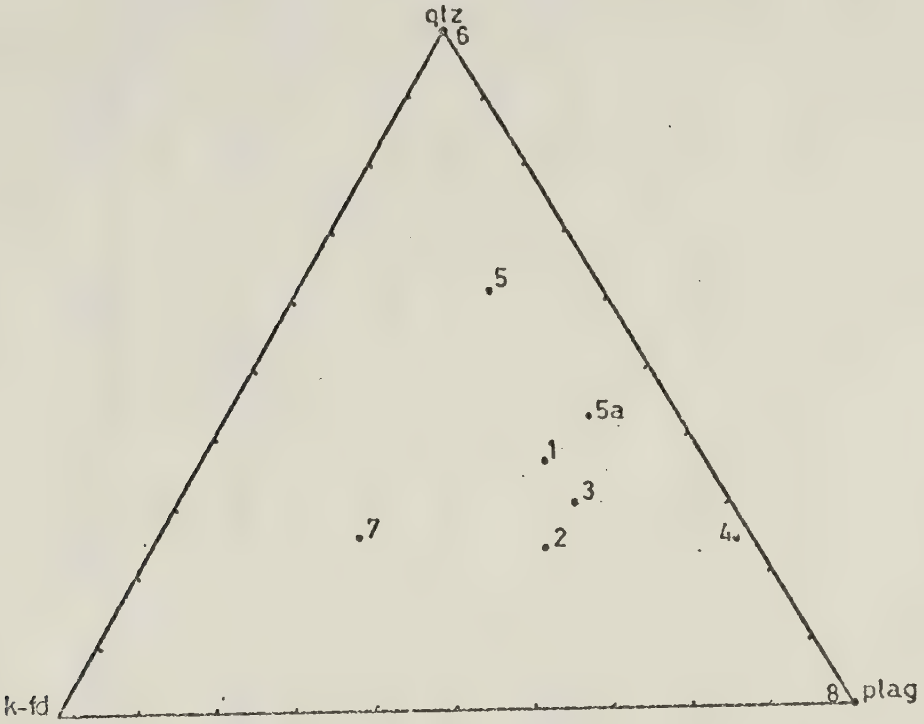


Fig. 30

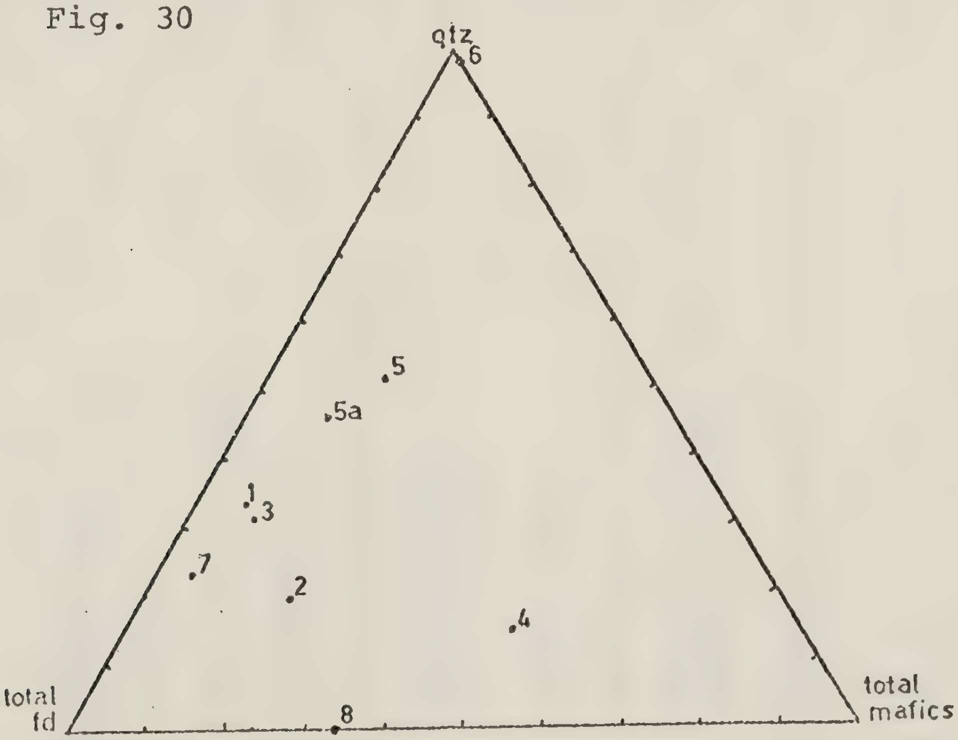


Fig. 31

TABLE X

AVERAGE PERCENTAGES OF MAJOR MINERALS

THEKULTHILI LAKE ROCK SUITE

(volume percent)

Rock Unit	Rock Type	n	Quartz	Total FD	K-Fd	Plag	Total Mafics
8	Diabase	1	0	64	0	64	36
7	Intrusive Granite	3	23.3	68.7	46	22.7	3.7
6	Mylonite	1	90	0	0	0	10
5	Nonacho Series (total)	58	43.8	27.7	10.5	17.4	12.5
5a	Nonacho Series (hornfelsic)	5	41	49	10.5	38	10
4	Basic Rocks	11	12.4	32.8	0.4	34.4	46.7
3	Retrograded Gneiss	35	25.9	60	16.7	41.7	7.4
2	Polymetamorphic (Reworked) Gneiss	9	28.9	51.9	18.6	33.7	14.4
1	Eastern Basement Gneiss	34	31.5	55.3	18.2	38.2	6.0

Note: Accessory minerals, alteration products, matrix, or opaque minerals not included in the above figures.

rock unit intrudes the Nonacho Series, and represents a high crustal level, probably late orogenic plutonic event.

Unit VIII: Diabase:

Figures 30 & 31 give typical mineralogical plots of diabase dykes found in the study area. Since field relations between the diabase and other rock units, clearly show the dykes to be the youngest rock unit in the area, cross-cutting all others, analyzing the mineralogy for purposes of discussing field relations is not necessary as with the other rock units.

7.2.3 Inter-Unit Comparisons

The composition of the major rock units represented in Figures 16 to 29, are given in Table X. Triangular plots of the average composition are shown in Figures 30 & 31.

Comparing the Nonacho Series with its basement gneiss rock units, (postulated as being possible source rocks for the Nonacho), trends are apparent. Polymetamorphic and especially retrograde rock units (Figures 18, 19, 20 & 21) are plagioclase-rich relative to quartz and K-feldspar content. However, the eastern basement gneisses show a trend towards more K-feldspathic mineralogy. (see Figure 16). This trend terminates in the Nonacho Series (Figures 24 & 25), at the quartz-rich and K-feldspar-poor area with a "tail" showing the route of the mineralogical trend. Total feldspar versus quartz content tie-line in Figures 19, 21 and 25 show a similar migration of point-

densities.

The likely reason for this mineralogical variation involves two processes: a later thermal event superimposed on the gneisses likely caused K-metasomatism (shown more dramatically in Unit VII), and the sedimentary-resistate series in the Nonacho Series diagrams caused the destruction of calcic feldspars and the beneficiation of quartz minerals.

A statistically more tenuous inter-unit comparison shows similarities between earlier basic or metabasic rock units (Figures 30 & 31) and later diabase dykes. Some meta-basic rocks may represent metamorphosed dykes of an older (pre-Hudsonian) age.

Figures 30 & 31 give average compositions of all rock units. The basement gneisses (Units I, II and III) group reasonably well, with intrusive granite Unit VII in Figures 30 & 31. A significant increase in K-feldspar is apparent in Figure 30, however suggesting K-metasomatism has occurred in Unit VII, typical of late stage high-level granites (Burwash and Krupicka, 1969). The Nonacho Series (Unit V) plots high towards the quartz end-member but the hornfelsic samples (Unit Va) trend towards more gneissic compositions. Significant mineralogical changes upon metamorphism of these sedimentary rocks are evident here.

Mylonite (Unit VI), Basic rocks (Unit IV), and Diabase (Unit VIII), plot well away from the main rock

types present, by virtue of their markedly different mineralogies.

7.3 OTHER METAMORPHIC CONSIDERATIONS

7.3.1 General Statement

Discovery of retrograde metamorphic mineral assemblages within Map Unit III prevented the application of the Barrovian method "first appearance of index minerals" for establishing the metamorphic facies of the rock. Alteration of gneisses by metamorphic processes is widespread in the study area, indicative of dynamothermal conditions outside those stability fields in which the gneisses were initially formed. Prograde metamorphism of gneisses and sedimentary rocks in the vicinity of altered or retrograded gneisses suggests a complex history of metamorphism which may be partly understood by considering pressure-temperature conditions indicated by the present mineralogy.

7.3.2 Stability Fields of Some Critical Minerals

The appearance of epidote and zoisite has indicated the greenschist-facies metamorphism of Nonacho Series sedimentary rocks or the retrogression of amphibolite-facies gneisses, as demonstrated in samples 21-6 and 21-7 respectively (Profile Four).

Although chlorite may be found in diagenetic sandstone as well as in amphibolite-facies gneisses, brown biotite is a definite indication of temperatures

encountered only during metamorphic episodes. Plates VIIIb-d show the growth of new brown biotite in the matrix of a cobble conglomerate. A hornfelsic texture is apparent and mineral deformation of the primary textures would indicate thermal metamorphism rather than dynamothermal. Sample 20-13 is very fine-grained biotite-rich metasedimentary rock which lies adjacent to the intrusive microcline granite. Hornfelsic rocks are found in two areas at least, within the Nonacho Series: Profile One and Salkeld Lakes. Henderson and Wilson mapped the adjacent granites as intruding the Nonacho in both places, which appears to be correct from metamorphic considerations.

The retrograde gneiss south of the Nonacho Series contains cobble-like quartz-feldspathic lenses throughout the unit. Retrograde greenschist metamorphism, has caused most of the hornblende present to alter to epidote and chlorite. The plagioclase remains quite calcite (An_{32}) which implies an amphibolite-facies formational temperature for the gneiss. The amphibolite-facies formational temperature is compatable with the mineral assemblages present in the polymetamorphic gneiss (Unit II) (samples 27-1 to 10) which lies in contact with the retrograde gneiss (Unit III).

Triangular diagrams (Figure 30) indicate a closer resemblance between Units II and III than between gneiss Unit II and Nonacho Unit V. Yet meta-Nonacho samples

(Unit Va) shift towards the gneissic plots (Figures 30 & 31). The possibility exists therefore, that Unit III was indeed a conglomeratic rock before metamorphism which is suggested by the quartz-feldspathic lenses pervading the unit, but the degree of metamorphism and dissimilarity with the adjacent Nonacho Series sedimentary rocks denies any possibility of the two units being time-equivalent. Structural evidence (Section 8.2) concurs with the metamorphic data.

7.3.3 Discussion

Reactivation of polymetamorphic gneiss and retrogression of a gneissic mantle around such a structure requires only one thermal pulse. However, the hornfelsic textures developed in the Nonacho Series sediments, as well as the pegmatite cross-cutting a mylonite zone beside the Nonacho, requires a thermal episode which postdates the Nonacho Series. The nonconformity underlying the Nonacho is well documented. Mineralogical and structural differences from the surrounding gneisses have been recorded (section 4.2.2 and section 8.2). The deposition of the Nonacho after initial regional metamorphism to amphibolite-facies, occurring as the result of rapid erosion of a block-faulted uplands or cordillera, seem feasible. A second, weaker thermal pulse with accompanying folding and faulting would then be necessary to deform the Nonacho strata and intrude upper level granites along

the margin of the basin, resulting in contact metamorphism of select portions of the Nonacho's periphery.

Evidence of pre- and post-Nonacho metamorphism places the series in the middle of an orogenic event. Another alternative to this intra-orogenic hypothesis to explain metamorphic features is the possibility that the Nonacho Series was deposited during the first brittle deformational stages of the orogeny, and was weakly metamorphosed and deformed during the main pulse. This model calls for the survival of this block of sedimentary rocks in a terrain of amphibolite-facies metamorphism, possibly preserved in a "cooler" zone between the Kenoran and Hudsonian tectonic fabrics. This second model has less geologic evidence than the intra-orogenic hypothesis to support it and is therefore considered less probable.

CHAPTER EIGHT

MAP UNITS

8.1 General Statement

The general geology of the thesis area given here represents a composite of early reconnaissance maps (Map 1), as well as field and petrologic data collected in the field seasons of 1958(Burwash and Taylor) and 1975 (Burwash and Donaghy). This compilation is presented on Map 2. It is interpretive along the Nonacho Series/granite-gneiss contact, but more descriptive away from the shores of Thekulthili Lake, due to a lack of field control in those areas. Aerial photographs and aeromagnetic maps were used to extrapolate field data to some extent, and to map structural features, especially faults.

The object of this thesis was not to map the areal extent of the various rock units, but to examine inter-unit relationships, in order to establish a geological sequence of events. The map units given here were originally formed because of the data collected (Chapter 4) and processed (Chapter 7) during the course of this thesis.

Field relations described by Burwash and Baadsgaard (1962) were somewhat verified and reconsidered by the writer and Dr. Burwash in subsequent work. The various rock units were assigned a position in a historical sequence of events, which will later be placed in a geological

time framework (Chapter Nine). The map units are shown on Map 2.

8.1.1 Map Unit 1

The rock unit considered to be the oldest encountered in the map area consists mainly of amphibolite-facies leucocratic gneisses (Map Unit 1). Where found in close proximity to the Nonacho Series, alteration of mafic minerals and plagioclases indicates low-grade metamorphic conditions superimposed upon the pre-existing gneisses.

This gneissic complex is usually coarse-grained, hematite-stained, and quartz-rich, with plagioclase more abundant that potassium feldspar (Figure 16). The basement gneisses are foliated and lineated with feldspar grains often sheared along their grain boundaries, and mafic minerals (e.g., biotite and hornblende) showing evidence of deformation. Near the contact with the Nonacho Series, hydrous minerals such as sericite, muscovite and chlorite, as well as epidote and zoisite, are noted replacing pre-existing mafic minerals. These low-grade minerals growing at the expense of medium-grade mafic and felsic minerals appear to be an expression of a second, weaker metamorphic event acting upon a hydrated, weathered basement.

Map Unit 1a designates this low-grade altered zone of leucocratic basement gneiss. The alteration appears to be more extensive near the contact with the Nonacho Series. It is speculated that the degree of similarity between this low-grade, altered gneiss and the low-grade metamorphosed Nonacho Series was the criteria used by Henderson (1939) to map the east shore of Thekulthili Lake as a series of alternating intrusive/non-conformable granites abutting the Nonacho Series (Map 1).

8.1.2 Map Unit 2

Map 2 shows the areal extent of this polymetamorphic amphibolite-facies gneiss present in the southern part of the thesis area. Textural and mineralogical evidence in outcrop and thin section suggests that the pre-existing gneiss of this area has been completely reconstituted as another biotite-hornblende-microcline gneiss. Many areas of Map Unit 2 contain microcline porphyroblasts in a relatively leucocratic gneiss which has a tri-modal character to its grain-size. Other parts of this complex are medium-grained, equigranular, but rodded hornblendic gneisses. Near the contact between this medium-grade polymetamorphic gneiss and a retrograde gneiss, discordant epidote veinlets are found cutting the hornblende gneisses. Map Unit 2 is postulated, then, to be a more complete recrystallization of the gneisses which form Map Units 1 and 1a, and is recognized only in this one area.

8.1.3 Map Unit 3

Map Unit 3 may be best described as chloritized biotite gneiss. It lies adjacent to Map Unit 2 (Map 2). Textural features show this unit to have a retrograde history. Thin section studies reveal this unit to be a medium- to coarse-grained, foliated, epidote-biotite-microcline plagioclase (An_{30}) gneiss.

8.1.4 Map Unit 4

Local occurrences of hornblende-epidote-chlorite-plagioclase-rich rocks are found on islands in Thekulthili Lake, lying between the gneissic southern shore of Thekulthili Lake, toward the Nonacho Series shore. These rocks are generally high in calcic plagioclase, and show epidote and chlorite growing at the expense of pre-existing hornblende. Their geologic origin is uncertain (Section 7.2.2, Unit IV). A metasedimentary and/or pre-Hudsonian diabasic origin seems most likely.

8.1.5 Map Unit 5

The Nonacho Series, as defined by Henderson (1939) and modified by the recognition of Map Unit 5a, collectively comprises Map Unit 5 on Map 2. This group of sedimentary rocks includes quartzites, arkoses, cobble-arkose, cobble-conglomerates, and greywackes. Some new metamorphic minerals found within this map unit were likely formed

under diagenetic conditions. They consist mainly of chlorite and sericite. Most of the clay fraction in these rocks has been converted to white mica flakes. No new epidote, zoisite or biotite were found in these samples and therefore this unit may be referred to as being essentially unmetamorphosed. It is important to emphasize that the Nonacho Series as defined as Map Units 5, 6 and 7 on Map 1 may not correspond directly to Map Unit 5 on Map 2, because of the recognition of a metamorphic aureole present in some locations along the periphery of the Nonacho Series sedimentary rocks.

Map Unit 5a

Map Unit 5a is shown to be a peripheral unit between distinctly metamorphosed gneisses and the Nonacho Series unmetamorphosed strata on Map 2. It is within this unit that rocks mapped as sedimentary rocks in the field, were found to contain thermal metamorphic mineral assemblages.

Petrographic evidence of thermal metamorphism is evident in samples 3644, 3647, 3635, 3650 and 3642, in rocks which appear unmetamorphosed in the field. A criteria used to define the boundary between metamorphosed and essentially unmetamorphosed sedimentary rocks is the presence or absence of the minerals epidote, zoisite, and

biotite if the rock composition allows its formation. Therefore, rocks mapped by the early workers as Nonacho Series may be classified as thermally metamorphosed or essentially unmetamorphosed: the distinction being made solely on the thin section mineralogy of the two rocks rather than on field observations.

The actual boundary between Map Unit 5a and Map Unit 5 (Map 2) is difficult to rigidly define because of the slight difference between the two. The location of this unit, especially along the eastern shore of Thekulthili Lake, should be regarded as an inferred contact, mapped with some local control, and extrapolated to other portions of the map area. Hornfels samples are included in this "meta-Nonacho" category.

8.1.6 Map Unit 6

In his preliminary report, Henderson (1939) refers to a "quartzite and arkose [which] have been baked to a fine-grained pink rock". This was petrographically determined to be ultramylonite. It is a leucocratic, crushed rock separating a thin wedge of hornfels (Map Unit 3) from the paragneissic units with which it is associated, in the west channel of Thekulthili Lake. A pegmatitic dyke was found cross-cutting this shear zone

mylonite, presumably from the granitic intrusion to the west. This suggests that the mylonite zone pre-dates the intrusion of the microcline granite.

8.1.7 Map Unit 7

Map Unit 7 consists of an intrusive, very coarse-grained, leucocratic microcline-rich granite, which has been stained salmon-pink in outcrop by the presence of hematite. Younger than Map Units 3 and 6, this microcline granite is the likely source for the leucocratic granite dykes and veins which intrude the gneisses at Profile Three and the mylonite at Profile One. The emplacement of this pluton also caused the contact metamorphism of a small wedge of adjacent country rock. Henderson (1939) and Wilson (1941) show this intrusive body to flank the western edge of both the Nonacho Series and the retrograded gneisses to the south.

8.1.8 Map Unit 8

Diabase dykes cut all the map units previously mentioned and are designated as Map Unit 8 on Map 2. Epidote, augite and plagioclase are the common minerals seen in thin section in these dykes, as well as a notable amount of black opaques, mainly magnetite. The presence of this mineral causes the diabase dykes to be expressed as

aeromagnetic highs on Map 3. The northwest (trending) strike of these dykes in the thesis area is compatible with the orientation of the Sparrow dyke Swarm. (McGlynn, et al, 1974).

8.2 Structural Conditions

The most striking structural feature in the thesis area is the physiographic depression which forms Thekulthili Lake. This arcuate trough coincides roughly with the eastern and southern contact of the Nonacho Series (Map Unit 5) and its neighbouring granites and gneisses. This contact may represent a block fault zone which has been accentuated by scouring from the last ice advance. The Nonacho Series (Map 1) was described by Henderson (1939) as a multi-folded synclinal structure, which was apparently infolded into the surrounding gneisses.

South of Thekulthili Lake, an envelope of gneisses (Map Unit 3, Map 2) is wrapped around a core of polymetamorphic gneiss. This suggests that this feature is a mantled gneissic dome. The limited strikes and dips recorded at Profiles Four, Five and Six support this theory. The axis of this mantled gneissic dome would then strike nearly parallel to the northeast portion of Thekulthili Lake. (Figure 13).

To the west, a reversal of dips in Map Unit 3 was noted near the microcline granite intrusive. This structural data as well as the presence of leuco-

cratic granitic veins cross-cutting the gneisses in this area, give evidence that the entire western area of the thesis area is a massive pluton which was forcibly intruded into the surrounding country rock. This plutonic dome was likely intruded along a pre-existing zone of weakness, expressed as the mylonite of Map Unit 6.

To the east is a peneplained section of basement gneisses (Map Unit 1) which has been heavily faulted and fractured. Several small bodies of sedimentary rocks and adjacent paragneisses were preserved as infolds in the basement gneisses, and show up well as aeromagnetic highs on Map 3.

Fault zones and fracture patterns cross-cut the thesis area. The most prominent of these are indicated on Map 2. Many faults have a northwest strike parallel to the Sparrow dyke Swarm. Immediately east of Bigpine Narrows, a dyke and a fault were found along the same lineament. Map 3 shows an aeromagnetic expression of the dyke, but no indication of the fault.

8.3 Summary

The thesis area shown in Map 2 consists of a variety of interrelated rock types. The dominant Nonacho Series (Unit 5) is a sedimentary sequence of rocks which have escaped metamorphism except for those areas which were in immediate contact with reactivated sections of the basement complex. The basement gneisses upon which the Nonacho

Series was deposited have been differentially reactivated. To the west, the basement material has formed an intrusive body of granite; to the south, the reactivated basement has formed a mantled gneissic dome, stratigraphically below the Nonacho Series, and to the east, the basement complex has been subjected to the weak retrograde metamorphism near the nonconformable contact of the low-grade meta-sedimentary rock unit (Unit 5a), likely influenced by percolating, hydrothermal solutions active at that time. Thermal metamorphism occurred in the northern portion of the thesis area near Salkeld Lake. The basement/gneissic complex has been strained or lineated farther away from the Nonacho Series. The reaction of the Nonacho Series of sedimentary rocks to this selective and weaker late metamorphic event has created a series of lower greenschist metasedimentary rocks, often displaying hornfelsic textures. These units form a discontinuous envelope in the western, southern, and eastern margins of the Nonacho rock unit shown on Map 2.

CHAPTER NINE

RADIOMETRIC AGE DATA

9.1 General Statement

Potassium/argon radiometric age dates have been determined in the study area by Burwash and Baadsgaard (1962) and the Geological Survey of Canada (Paper 67-2). Table XI gives the coordinates of these dates (plotted on Figure 34) as well as the mineral dates and type of rock that was sampled. The ages of granites and gneisses range from "pre-Hudsonian" to late-Hudsonian, and the age of the diabase dykes is post-Hudsonian.

9.2 Observations

Some general patterns are present on Figure 34. A line drawn sub-parallel to the intrusive granite west of Thekulthili Lake separates dates older than 1850 m.y. to the east from younger dates to the west. Burwash and Baadsgaard (1962) regard their older age determinations (2240 to 2420 m.y.) as "survival values", dates which have been established initially during the older Kenoran orogeny, and partially updated by the later Hudsonian event. Those dates west of the line giving ages from 1745 to 1850 m.y. are all grouped within the Hudsonian event (with exception of the diabase dyke dates). These dates are in rock units which have field relations that support these findings: pegmatite from the western pluton, monometamorphic gneiss, or reactivated gneiss near hornfels

sample 3644. The dates east of the line are in boulders or gneissic basement mapped as "older granitic", which is non-conformable to the Nonacho.

9.3 Discussion

Two populations of isotopic dates appear (excluding the diabase sample) in Table XI: one group of samples give ages between 1790 and 1850 m.y., a second population ranges from 1940 ± 60 to 2420 m.y. The younger dates likely represent Hudsonian ages of those rocks either formed or completely "re-set" by the Hudsonian thermal pulses. The older and more scattered group is an expression of partial "re-setting" of the older Kenoran dates.

The time 1850 m.y. is selected as representing the approximate mid-point of the Hudsonian orogeny (Stockwell, 1972). Most K/Ar dates representing the Hudsonian event are of this age or slightly younger.

McGlynn (1976) considers the ages obtained from whole-rock radiometric age determination techniques run on diabase dyke samples to be too young, due to daughter-product loss caused by alteration of the dykes sampled. He states that the most reasonable date to affix to the Sparrow Dyke swarm is about 1700 m.y.

The spatial distribution of the age dates determined in the thesis area is shown on Figure 34. To the north, lying on the "younger" side of the proposed thermal line, dates obtained by Burwash and Baadsgaard from sericite and biotite mineral separates from sericitized granite gneiss are only slightly younger than the date obtained from a biotite mineral separate from the apparently unaltered basement gneiss (1790-1800 m.y. vs. 1850 m.y.). The time interval 1800 to 1850 m.y. is assumed to coincide with the time of growth of unaltered, brown biotite in the matrix of the Nonacho conglomerate along the east shore of Salkeld Lake.

Hudsonian dates on the south shore of Thekulthili Lake are present in the retrograde gneiss unit.

Survival values lie east of the thermal line drawn on Figure 34. These dates were determined from granitoid boulders within the Nonacho Series, and from the gneissic basement unit. These older values occur in a gneiss lithologically similar to the unit dated farther north at 1850 m.y. Selective reactivation within one gneissic unit is evident.

TABLE XI

THEKULTHILI LAKE AREA ISOTOPIC AGE DATES (K/AR)

Location		Material Dated	Mineral Dated	Age (m.y.)	Source
N. Latitude	W. Longitude				
61° 07'	110° 16' 02"	Diabase	Whole rock	1550± 170	1
60° 56' 12"	110° 21' 24"	Pegmatite	Muscovite	1845± 58	1
61° 03' 48"	110" 03' 12"	Quartz diorite boulder	Muscovite	1940± 60	1
60° 57' 30"	110° 16' 48"	Granodiorite	Muscovite	1785± 55	1
61° 03' 30"	110° 01' 42"	Granite	Muscovite	2175± 65	1
61° 12' 54"	109° 56' 12"	Granodiorite near nonconformity	Muscovite	1745± 55	1
61° 26'	109° 47'	Gneiss near nonconformity	Sericite	1790	2
61° 26'	109° 47'	Gneiss near nonconformity	Biotite	1800	2
61° 19'	109° 49'	Biotite gneiss	Biotite	1850	2
61° 06'	109° 57'	Hornblende gneiss (amphibolite pod)	Hornblende	2240	2
61° 04'	109° 57'	Pegmatite boulder	Muscovite	2420	2
61° 04'	109° 57'	Granite boulder	Muscovite	2260	2

Compiled from (1) G.S.C. Paper 67-2 and,(2) Burwash & Baadsgaard, (1962).

Location of Isotopic Age Dates and Thermal Line

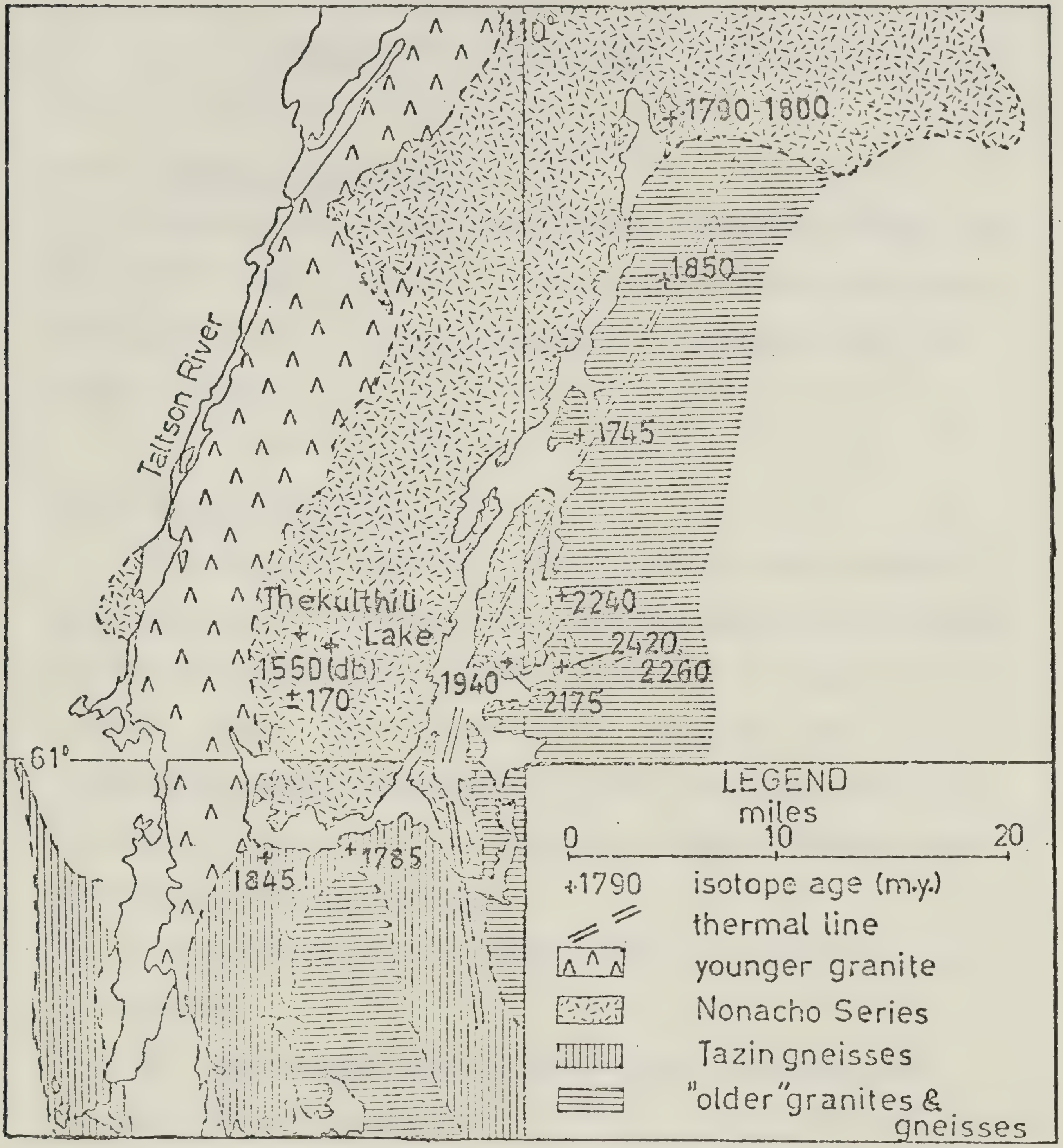


Figure 32 (adapted from Burwash & Baadsgaard, 1962).

CHAPTER TEN

SUMMARY AND CONCLUSIONS

10.1 General Statement

Characteristics of the Nonacho-basement contact appear to be contradictory: intrusive relations are seen in some areas while a non-conformity is evident along the same contact.

10.2 Field Relations

The Nonacho Series is shown to have been metamorphosed with the basement granites and gneisses upon which it was originally deposited (Chapter 4), by way of a second thermal pulse occurring in selected areas of the basement complex. Radiometric dates combined with petrography suggest that two Hudsonian thermal pulses (pre- and post-Nonacho) occurred.

Field relations supporting this interpretation are as follows:

1. The Nonacho Series was folded, faulted, and thermally metamorphosed.

2. Textural and mineralogical differences exist in the granitic rock units: the western microcline granite appears to have undergone K-metasomatic processes relative to the gneissic units.

3. Non-conformable field relations (Burwash, 1958) between the Nonacho and "older granite" are found along the same contact on which intrusive relations are recorded (Henderson, 1936).

4. Retrograde and polymetamorphic gneisses are both present, implying a complex metamorphic history.

A reworked gneissic complex underlies the retrograde gneisses, representing the core of a domal structure. This core was recrystallized under amphibolite-facies metamorphic conditions. The contact between the two gneisses is distinctive.

The Nonacho Series is therefore assigned an intra-Hudsonian time-stratigraphic position (see Table XII, Section 10.5).

10.3 Local Observations

Diagnostic greenschist-facies mineral assemblages (Chapter Three) are present in areas mapped as Nonacho Series sedimentary rocks (sample 3647), in the northern portion of Thekulthili Lake, also along its eastern contact.

Henderson's "older" and "younger" granites (1937) which he defined solely on the basis of the non-conformable/intrusive field relations with the Nonacho Series are an expression of the degree of metamorphic "welding" between the Nonacho Series and the adjacent altered

gneisses. Invariably, the completeness of the "weld" between the two rock units is governed to a large extent by the nature of the basal Nonacho Series unit. Boulder conglomerates create the appearance of a non-conformity whereas arkosic sandstones, which have undergone weak metamorphic processes to the same extent to which the adjacent granitic basement gneisses have been altered, created a contact which appears intrusive.

The southern gneissic dome has retrograde gneisses along all three flanks. These gneisses have been intruded by the microcline granite pluton in the west. Structural evidence suggests that the domal structure plunges northeastwards. The sharp contact between retrograde and polymetamorphic gneisses, is then an unconformity between the "Tazin Equivalent" gneisses, and its basement material. The poor preservation of the Nonacho Series/gneiss non-conformity has played a fundamental role in the confusion which has arisen over the age-relationships of the Nonacho Series.

10.4 Regional Observations

The Nonacho Series is an essentially unmetamorphosed sequence in an arcuate band of slightly to highly metamorphosed rocks (see Figure 2). Various tectonic elements expressed aeromagnetically on Map 3, are important in the regional interpretation. The study area is

situated along the border of two divergent fundamental lineament systems. The prominent north-south fabric to the west is believed to reflect the earlier Kenoran tectonic events. The northeast-trending fabric is typical of later Hudsonian orogenic events.

This apparent junction of the Kenoran and Hudsonian metamorphic fabrics is manifested in several ways within the thesis area. Isotopic age determinations (Figure 34, Table XI), give both Kenoran and Hudsonian dates, evidence of thermal "overprinting". Polymetamorphic gneisses and Tazin (retrograde) gneisses in the southern thermal dome indicate at least two major regional metamorphic events.

The microcline-rich granite pluton (Map Unit 7, Map 2) which was emplaced during the final stages of the Hudsonain, is evidence that potassium metasomatism, a common phenomena with Hudsonian-age rocks (Burwash and Krupicka, 1969), has occurred in the study area. This pluton may represent an anatectic "melt" along a zone of steep thermal gradients.

Tazin-equivalent gneisses are likely time-correlative with the monometamorphic Upper Tazin sequence in the Uranium City-Beaverlodge Lake area, Saskatchewan (Christie, 1953). The Tazin map unit extends from Saskatchewan to an area immediately east of Thekulthili

Lake, forming a continuity between the type-area of the Tazin Group, and the Thekulthili Lake area.

The Nonacho Series is then placed stratigraphically above the Tazin-equivalent rocks because of the petrological-metamorphic criteria outlined in Chapter 7, as well as field relations. The folded and weakly metaphosed condition of the Nonacho Series makes the unit a possible time-correlative with the Thluicho Lake Series described by Scott (1972). Scott describes a post-Tazin, pre-Martin sequence of sedimentary strata deposited in two localized basins, which are weakly metamorphosed, but are not gradational into the underlying Tazin gneisses. The area described is 25 miles northwest of Uranium City, Saskatchewan, and lies within the belt of rocks indicated in Figure 2. These rocks may be geographically restricted expressions of the intra-orogenic sedimentary processes which appear to account for the Nonacho Series.

10.5 Geologic History of the Thekulthili Lake Area

Local and regional studies allow the reconstruction of the geological history of the thesis area, with respect to the history of the western Canadian Shield. (Table XII).

Kenoran tectonic fabric preserved as aeromagnetic highs and lows west of Thekulthili Lake (Map 3) is the expression of a gneissic complex which pre-dates the "Tazin-Equivalent" and Nonacho Series. This complex was

likely comprised of synkinematic and late stage epizonal plutons, intruding volcanic and sedimentary sequences, which would have undergone regional metamorphism and some local contact metamorphism at the time. This Archean complex provided the source material for the Tazin-equivalent sediments, and the basement upon which the sediments were deposited. During the pre-Hudsonian period, mylonitization and block-faulting occurred at the same time as regional cataclasis (Burwash and Krupicka, 1969) was occurring elsewhere.

The Hudsonian regional orogenic event metamorphosed the Tazin-equivalent sedimentary rocks and infolded them into the basement complex. The Nonacho Series was deposited in a block-faulted depression shortly thereafter. Metamorphism during a late Hudsonian plutonic event altered the eastern unconformable edge of the demi-graben, in which the unmetamorphosed Nonacho Series and metamorphosed portions of the sedimentary pile were preserved (Figure 16). To the south, the remetamorphosed Kenoran basement complex was doming upwards, manifesting itself here as a mantled gneissic dome, with Tazin-equivalent retrograde gneiss wrapped around the core. High level plutonism reflecting potassium-metasomatism during this event intruded both the mylonite zone marking the western edge of the Nonacho Series depositional basin and the gneisses of the western flank of the mantled

gneissic dome to the south.

Later, faulting was accompanied by diabase dykes, which cut all lithologies present in the area. Uplift and erosion followed this last metamorphic event. In recent time, glaciation has accentuated the folded strata of the Nonacho Series and the foliation of the basement complex.

TABLE XII

TIME-STRATIGRAPHIC SEQUENCE OF EVENTS, THEKULTHILI LAKE AREA, N.W.T.

ERA	EVENT	AGE (m.y.)
	- Glaciation	Recent
Paleohelikian	- Uplift and erosion. - Faulting, diabase dykes cut all rocks.	1700 m.y.
Late Hudsonian (second "pulse")	- Orogenic reactivation intrudes epizonal granite pluton and causes hornfelsic metamorphism of Nonacho Series. - Deposition of Nonacho Series in intra-orogenic demi-graben.	1800 m.y.
Early Hudsonian	- Folding, faulting, mylonitization. - Gneissic doming, metamorphism of Tazin Group.	∿1900 m.y.
	- Faulting, mylonitization, cataclasis.	
Aphebian	- Deposition of Tazin-equivalent sedimentary rocks. - Uplift and erosion.	
Kenoran	- Late stage granite plutons. - Metamorphism, gneissification and plutonism.	2600 m.y.

BIBLIOGRAPHY

ALCOCK, F.J.,(1963). "Gold Deposits of Lake Athabasca". Can. Min. Met. 292, p. 531.

AUGUSTITHUS, S.S.,(1973). "Atlas of the Textural Patterns of Granites, Gneisses, and Associated Rock Types". Amsterdam, Elsevier.

BAADSGAARD, H. and GODFREY, J.D., (1972). "Geochronology of the Canadian Shield in Northeastern Alberta, Part II: Charles-Andrew-Collins Lake Area". C.J.E.S., 9, pp. 863-881.

BAER, A.J., (Ed.) (1970). "Symposium on Basins and Geosynclines of the Canadian Shield". G.S.C., Paper 70-40.

BERRY, L.G. and MASON, B., (1959). "Mineralogy". W.H. Freeman, San Francisco.

BURWASH, R.A. and BAADSGAARD, H., (1962). "Yellowknife-Nonacho Age and Structural Relations". in: The Tectonics of the Canadian Shield, (J.S. Stevenson, Ed.). Roy. Soc. Can. Spec. Publ. 4. U. of Toronto Press, Toronto, pp. 22-29.

BURWASH, R.A. and KRUPICKA, J., (1969). "Cratonic Reactivation in the Precambrian Basement of Western Canada, Part I: Deformation and Chemistry". C.J.E.S., 6 (6), pp. 1381-1396.

————————————————, (1970). "Cratonic Reactivation in the Precambrian Basement of Western Canada, Part II". C.J.E.S., 7, pp. 1275-1294.

BROWN, I.C. and WRIGHT, G.M., (1957). "Proterozoic Rocks of the Northwest Territories and Saskatchewan". in: The Proterozoic of Canada, (J.E. Gill, Ed.). Roy. Soc. Can. Spec. Publ. 2. U of Toronto Press, Toronto, pp. 79-92.

CAMSELL, C., (1916). "An Exploration of the Tazin and Taltson Rivers, Northwest Territories. G.S.C. Memoir 84.

CHRISTIE, A.M., (1953). "Goldfields-Martin Lake Map Area, Saskatchewan". G.S.C. Memoir 269.

HENDERSON, J.F., (1937). "Nonacho Lake Area, Northwest Territories". G.S.C. Prelim. Rept. 37-2, Dept. Mines and Resources.

HENDERSON, J.F., (1939). "Taltson Lake, District of Mackenzie". G.S.C. Map 525A.

—————————, (1939). "Nonacho Lake, District of Mackenzie". G.S.C. Map 526A.

—————————, (1948). "Extent of Proterozoic Granitic Intrusions in the Western Part of the Canadian Shield". Roy. Soc. Can., Series III, Sec. IV, 42, pp. 41-54.

HOLMES, A.C., (1945). "Principles of Physical Geology". The Ronald Press Co., New York.

HOFFMAN, P., (1973). "Evolution of an Early Proterozoic Continental Margin: The Coronation Geosyncline and Associated Aulocogens of the Northwest Canadian Shield". in: Evolution of the Precambrian Crust. Phil. Tran. Roy. Soc., London, p. 1.

—————————, (1973). "Aphebian Supracrustal Rocks of The Athapuscow Aulocogen, East Arm of Great Slave Lake, District of Mackenzie". G.S.C. Paper 73-1A, pp. 151-156.

KERR, P.H., (1959). "Optical Mineralogy". 2nd Edition, McGraw-Hill, Toronto.

KRUPICKA, J. and SASSANO, G.P., (1972). "Multiple Deformation of Crystalline Rocks in the Tazin Group, Eldorado Fay Mine, Northwest Saskatchewan". C.J.E.S., 1, pp. 422-432.

McGLYNN, J.C., HANSON, G.N., IRVING, E. and PARK, J.K., (1974). "Paleomagnetism and Age of Nonacho Group Sandstones and Associated Sparrow Dikes, District of Mackenzie". C.J.E.S., 11, pp. 30-42.

McGLYNN, J.F., (1966). "Thekulthili Lake Area". G.S.C. Paper 66-1A, pp. 32-33.

—————————, (1969). "Churchill Province". in: Geology and Economic Minerals of Canada, (R.J.W. Douglas, Ed.). G.S.C., 5th Edition, pp. 85-101.

—————————, (1970). "Study of the Nonacho Group of Sedimentary Rocks, Nonacho Lake, Taltson and Reliance Areas, District of Mackenzie". G.S.C. Paper 70-1A, (Parts of E, F, K.), pp. 154-155.

—————————, (1971). "Stratigraphy, Sedimentology and Correlation of the Nonacho Group, District of Mackenzie". G.S.C. Paper 71-1A, pp. 140-142.

MEHNERT, K.R., (1968). "Migmatites and the Origin of Igneous Rocks". Amsterdam, Elsevier.

MIYASHIRO, A., (1972). "Metamorphism and Metamorphic Belts". John Wiley, New York.

MOORHOUSE, W.W., (1959). "The Study of Rocks in Thin Section". Harper & Row, New York.

MORTON, R.D., (1974). "Sandstone-type Uranium Deposits in the Proterozoic Strata of Northwestern Canada". in: Formation of Uranium Ore Deposits. International Atomic Energy Agency, Vienna, pp. 255-273.

MULLIGAN, R., (1956). "Hill Island Lake (West Half), District of Mackenzie". G.S.C. Prelim. Map 55-25.

MULLIGAN, R. and TAYLOR, F.C., (1969). "Hill Island Lake, District of Mackenzie". G.S.C. Map 1203A.

PRICE, R.A. and DOUGLAS, R.J.W. (Eds.), (1972). "Variations in Tectonic Style in Canada". G.A.C. Spec. Paper 11, Business and Economic Service Ltd., Toronto.

SASSANO, G.P. and MORTON, R.D., (1976). "The Current Status of Geochronology in the Beaverlodge Area". Presented at Edmonton G.A.C. Meeting. (Unpublished).

SCOTT, B., (1972). "Thluicho Lake (East Half)". in: Summary Report of Geological Investigations, Saskatchewan Dept. of Min. Res. L.S. Beck (Ed.), pp. 26-29.

STOCKWELL, C.H., (1932). G.S.C. Summary Report Part C: 55.

—————————, (1972). Revised Precambrian Time Scale for the Canadian Shield. G.S.C. Paper 72-52, p. 2.

TAYLOR, F.C., (1956). "Hill Island Lake (East Half)", District of Mackenzie". G.S.C. Prelim. Map 55-16.

TURNER, F.J., (1967). "Metamorphic Petrology". McGraw-Hill, San Francisco.

WANLESS, , STEVENS, R.D., LACHANCE, G.R. and RIMSAITE, R.Y.H., (1967). "Age Determinations and Geologic Studies". G.S.C. Paper 67-2.

WATANABE, R.Y., (1962). "The Geology of the Waugh Lake Area, Northeast Alberta". Unpubl. M.Sc. Thesis, Univ. of Alberta, Edmonton.

_______________, (1966). "Petrology of Cataclastic Rocks of Northeast Alberta". Unpubl. Ph.D. Thesis, Univ. of Alberta, Edmonton.

WILSON, J.T., (1941). "Fort Smith, District of Mackenzie". G.S.C. Map 607A.

WINKLER, H.G.F., (1967). "Petrogenesis of Metamorphic Rocks". 2nd Edition, Springer-Verlag, New York.

_______________, (1974). "Petrogenesis of Metamorphic Rocks". 3rd Edition, Springer-Verlag, New York.

APPENDIX I

THESIS SUITE PETROGRAPHIC DESCRIPTIONS

PETROGRAPHIC DESCRIPTIONS

PROFILE ONE

MINERAL	PERCENTAGES																			
Sericite	6	3	10	3	2	Tr.		2	2											
Muscovite		2	5				1	2	Tr.	Tr.				1	1					
Chlorite				Tr.	1	2		4		5		1								
Biotite							3	2	Tr.		3	7	Tr.	5	3					
Zoisite					1		2	1	2	2	1	1	1	1						
Epidote	Tr.	2	1		1	2	1	3		1		Tr.	Tr.	Tr.						
Hornblende												5								
Pyroxene																				
Quartz	50	65*	60*	30*	80*	35*	40	15	25	30	37*	20	90		15					
Plagioclase An 0-15		10*			8*		53	70*	Tr.		30	50			10					
Plagioclase An 15-30	15		20*			20*														
Orthoclase										20	23	15								
Microcline	25	15*	5*	16*	7*	25*			35*						73					
Perthite																				
Opaques	2	Tr.		Tr.	Tr.			Tr.		2	1		8	2	4					
Carbonate	1	1	3	1		Tr.	Tr.		1	2	5	Tr.								
Accessory Minerals							Tr.	Tr.				Tr.								
Ground Mass/tissue			5	50		15				40			89							
Sample Numbers	20-17	-16	-16	12	14	15	9	8	6	18	19	20	21	23	24					

*Denotes detrital minerals

PETROGRAPHIC DESCRIPTIONS

PROFILE TWO

MINERAL	PERCENTAGES																			
Sericite	15	10	5	15	18	4	1	3												
Muscovite		Tr.*				Tr.		Tr.												
Chlorite			1					Tr.												
Biotite						5	5	2												
Zoisite						Tr.														
Epidote			Tr.	1	Tr.															
Hornblende						50														
Pyroxene																				
Quartz	50	40	78	50*	42		35	30												
Plagioclase **An 0-15**	5	20					28	30												
Plagioclase **An 15-30**			7	20*	20	39														
Orthoclase																				
Microcline			3	5*	10*															
Perthite							30	35												
Opaques	Tr.	Tr.*	2				1	1												
Carbonate			3	3	5	Tr.														
Accessory Minerals					Tr.	1	1													
Ground Mass/tissue	25	30*			4															
Sample Numbers	20-5	4	3	2	1	19-14	13	12												

*Denotes detrital minerals

PETROGRAPHIC DESCRIPTIONS

PROFILE THREE

MINERAL	PERCENTAGES																			
Sericite	2	2	3	3	4		5	3		3										
Muscovite	1									Tr.										
Chlorite		4								Tr.										
Biotite	4	1	1			15	28	10		2										
Zoisite																				
Epidote						2														
Hornblende						30			2											
Pyroxene									1											
Quartz	35	20	39	30	25		16	25	70	30										
Plagioclase An 0-15		56		10						30										
Plagioclase An 15-30+	20		55		23	51	56	50	16											
Orthoclase								5												
Microcline	38	15			45				12											
Perthite	Tr.			58					Tr.	35										
Opaques				Tr.	2			1		1										
Carbonate		1																		
Accessory Minerals	Tr.	1	1	1	Tr.	1	1	1	Tr.											
Ground Mass/tissue																				
Sample Numbers	19-6	4	3	11a	9	8	7	10	11	12										

*Denotes detrital minerals

PETROGRAPHIC DESCRIPTIONS

PROFILE FOUR

MINERAL	PERCENTAGES																			
Sericite	3	3	2	3	15	1	2	4	1	Tr.	1	Tr.	Tr.	1			Tr.	Tr.	Tr.	Tr.
Muscovite	2*		2																	
Chlorite				1	3		1	6	4		2		Tr.	Tr.					Tr.	
Biotite						9	15			2		3	4	Tr.	25	25	3	3	3	2
Zoisite																				
Epidote		5	Tr.	3	1	1	1	2		Tr.	1	Tr.	2	Tr.	2	2	2	2	1	Tr.
Hornblende						3							3	4	15	15	2	1	2	
Pyroxene																				
Quartz	60*	45*	50*	20	15	20	15	25	16	20	40	35	35	45	10	10	35	65	25	20
Plagioclase An 0-15	10*		15*		60			62		30				45	30	30				
Plagioclase An 15-30+		10*		66		63	30		60		53	40	25				40	16	15	34
Orthoclase									14											
Microcline	5*	15*	10*	5		3	30			23		20	20	5	13	13	15	12	53	23
Perthite																				
Opaques	Tr.	3	1	1	1		Tr.	Tr.	3		1	Tr.	Tr.				1			
Carbonate				1	5			1	1	Tr.									Tr.	Tr.
Accessory Minerals							Tr.	Tr.	3	1		1			Tr.	Tr.	Tr.	Tr.	Tr.	1
Ground Mass/tissue	20	20	20												5	5				
Staurolite									2											
Sample Numbers	21-2	5	6	13	12	9	10	11	27-12	27-7	27-8	27-9	27-10	1	2	3	4	5	6	7

*Denotes detrital minerals

PETROGRAPHIC DESCRIPTIONS

PROFILE FIVE

MINERAL	PERCENTAGES																			
Sericite	15	15	5	1	2				1	1										
Muscovite	1*	Tr.				2		2												
Chlorite		1	2				1	2	4											
Biotite			20	3	15	2				5										
Zoisite			7	1	5	1				2										
Epidote	Tr.		10		10		27	Tr.	4	3										
Hornblende				70			10													
Pyroxene																				
Quartz	60*	75*	54	2	5	80	30	55	8	54										
Plagioclase An 0-15		1*																		
Plagioclase An 15-30+	30*			20	60		30	2	80	15										
Orthoclase	18*	4*																		
Microcline						15		30		20										
Perthite																				
Opaques	1	2	2		1	Tr.														
Carbonate		5			1	Tr.	Tr.	1	Tr.											
Accessory Minerals			Tr.	2	1	Tr.	1		1	1										
Ground Mass/tissue								8												
Sample Numbers	18-1	3	4	5	6	7b	8	9	10	14a										

*Denotes detrital minerals

PETROGRAPHIC DESCRIPTIONS

PROFILE SIX

MINERAL	PERCENTAGES																			
Sericite			10			3*	1	1	1	2	5	1		Tr.	5		1	1	1	Tr.
Muscovite		1	1*				Tr.							1				3	2	
Chlorite		1	1			1		3	16	4	1	2	17	Tr.						
Biotite							1						6	12	5	1		10	6	8
Zoisite							1	1			1							1		Tr.
Epidote														Tr.	Tr.				Tr.	2
Hornblende																				
Pyroxene																				
Quartz	12*		55	25	3	79*	40	30	15	15	50	15	10	3	25			15	30	30
Plagioclase An 0-15			8				20	20	35		15	40								
Plagioclase An 15-30										35			35	75	30	89	99	70	60	58
Orthoclase			2	5	10		17							5						
Microcline	8*							20	20	40	25	25	30		10	10				
Perthite																				
Opaques	1	6	2				1	1	1	1	2		1			Tr.			Tr.	
Carbonate	Tr.		Tr.				4		10	8	2	2		3						Tr.
Accessory Minerals										Tr.			Tr.			Tr.		Tr.		
Ground Mass/tissue	10	20	20	70	87	20	14	24				15			25					
Sample Numbers	24-7a	6	5a	3	2	1	8b	9	10	11	12	13	14	15	16	17	18	19	20	21

*Denotes detrital minerals

PETROGRAPHIC DESCRIPTIONS

PROFILE SEVEN

MINERAL	PERCENTAGES																			
Sericite					6	Tr.														
Muscovite	Tr.	Tr.	Tr.	Tr.																
Chlorite				1	1															
Biotite				Tr.	Tr.															
Zoisite																				
Epidote																				
Hornblende																				
Pyroxene																				
Quartz	45	50	50	45*	50	20														
Plagioclase An 0-15																				
Plagioclase An 15-30+	24	35	35	13	15															
Orthoclase																				
Microcline	30	15	15	5	10	10														
Perthite																				
Opaques	Tr.	2	2	3	2															
Carbonate		1	1	1																
Accessory Minerals																				
Ground Mass/tissue				30		70														
Sample Numbers	25-3	2	1	4	5	6														

*Denotes detrital minerals

PETROGRAPHIC DESCRIPTIONS

PROFILE 1958 Rocks

MINERAL	PERCENTAGES																			
Sericite	3	8			45	40	2	7	2	Tr.	12	1	3	15			5	2	1	2
Muscovite	1	Tr.	2*+1		1	1	3		3			4		1	5	3		1		1
Chlorite	2	6	4		3	3	4	1				Tr.	13					2		
Biotite	2							10		10	5		2			2	5		12	4
Zoisite	1						1	1	1	2		Tr.		2			3		1	
Epidote	1	5	Tr.	2			5	5	3	3	2		5		2	1	3		2	Tr.
Hornblende																				
Pyroxene																				
Quartz	30	15			40	50	10	27	35	15	80	90	15	35	70	63	20	70	15	20
Plagioclase An 0-15					5	5	70		30			5		30	20	20				50
Plagioclase An 15-40	15	55						38		65			65				62	15	68	
Orthoclase		10																		
Microcline	30						2		17	2		Tr.	Tr.	13		1	2	10	1	23
Perthite																				
Opaques	1		5	1	5	2	3				1	1								
Carbonate	3		2	5					10	1			2	6	3	10	1	3		Tr.
Accessory Minerals	1	1		Tr.			Tr.	Tr.		Tr.			Tr.	Tr.	Tr.		1		Tr.	1
Ground Mass/tissue			85	81															1	Tr.
Sample Numbers	36-35	36-36	36-38	36-37	36-40	36-39	36-43	36-42	36-45a	36-44	36-47	36-48	36-50	36-49	36-46	36-45b	36-52	36-51	36-54	36-53

*Denotes detrital minerals

PETROGRAPHIC DESCRIPTIONS

PROFILE 1958

MINERAL	PERCENTAGES																			
Sericite	Tr.	Tr.		3	20	45		1	3		2	2	1			3	25			10
Muscovite			3				3	3				1	1	2	5		6			
Chlorite	3	3		1					4			1	1		3				5	1
Biotite			20			5	1	5			20	3		5		27		15		
Zoisite	1	1	Tr.	10	1						Tr.			.2		2		5	2	
Epidote			2	3	3			3	3		4	1				3		25	3	2
Hornblende																		5		
Pyroxene																				
Quartz	30	30	25	30	23	40	35	30	25	30	10	20	30	30	30	Tr.	40	10	20	35
Plagioclase An 0-15			45	25	25				50	40			35	45			20		42	40
Plagioclase An 15-40	35	35					33	45			60	70			55	60		10		
Orthoclase																				
Microcline	30	30	Tr.	15	23	10	25	10	20	20			30	15	1		5		2	2
Perthite																				
Opaques	1	1		3	2		3	Tr.	3		5	1	1	Tr.	3			1	3	5
Carbonate			2	2					Tr.			Tr.			3	3	1	1	2	
Accessory Minerals	Tr.	Tr.	2	1	Tr.			2		2	Tr.			1			Tr.	1	6	Tr.
Ground Mass/tissue																				
Augite																		5		
Sample Numbers	36-57	36-56	36-55	36-60	36-59	36-58	36-64	36-63	36-62	36-61	36-65b	36-65b	36-67	36-66	36-69	36-68	36-71	36-70	36-77	36-76

*Denotes detrital minerals

PETROGRAPHIC DESCRIPTIONS

PROFILE 1958

MINERAL	PERCENTAGES																			
Sericite		20	3	15	3		5	2	45	10	3			2	55	3		2		
Muscovite													1			1		Tr.		Tr.
Chlorite		70	2	20	2	2	2	1		3		3	3	2	15	2	Tr.	Tr.	Tr.	
Biotite											10		Tr.			1	10	5		1
Zoisite			7	7			Tr.				2				4	Tr.	3			2
Epidote			3	3						Tr.	3			Tr.	3	Tr.	1		1	3
Hornblende											55			3		1				50
Pyroxene																				
Quartz	79	2	17	5	45	20	50	55	40	40		25	60		20	45	25	25	35	Tr.
Plagioclase An 0-15	15	5	60	35	40	45	22	20	15	30	25	40		60		30	45	55	10	40
Plagioclase An 15-30													17							
Orthoclase																				
Microcline	5			4	5	30	15	20		15		30	20	25		15	15	10	50	
Perthite																				
Opaques		3	5	1	5	3	3	1						4					3	Tr.
Carbonate	1			2	1		1	1		2		2		1	3	Tr.		2		Tr.
Accessory Minerals				5	Tr.		Tr.	1		1	1		Tr.	Tr.		1	3			Tr.
Ground Mass/tissue																1				1
Sample Numbers	36-73	36-74b	36-79	36-78	36-80	36-90	36-93	36-92	36-99	36-96	37-05	36-73	36-92	37-06	36-95	37-09	37-10	37-11	37-12	37-04

*Denotes detrital minerals

PETROGRAPHIC DESCRIPTIONS

PROFILE 1958

MINERAL	PERCENTAGES																			
Sericite	10		5		46	20	2	38	15	6	1									
Muscovite						2	Tr.			Tr.		2	Tr.	1						
Chlorite	15	10		1	3		2	8	2	Tr.	Tr.		3	2						
Biotite																				
Zoisite		17						1				1								
Epidote		6																		
Hornblende													3							
Pyroxene																				
Quartz	30		60	40	30	75	33	15			42	40	25	65						
Plagioclase An 0-15		64	15		12				50			20	24	2						
Plagioclase An 15-30				15			49				25									
Orthoclase																				
Microcline			20	41			12		13		30	35	40	2						
Perthite																				
Opaques	5	3	Tr.	3	1	3	2	27		10	1		3							
Carbonate	40						Tr.	2	20	2		2	Tr.							
Accessory Minerals								1			1		1	2						
Ground Mass/tissue					10			10		80				20						
Sample Numbers	37-17	37-18	37-34	37-35	37-37	37-36	37-32	37-19	37-25	37-31	37-38	36-74a	36-72	37-16						

*Denotes detrital minerals

MAP 2

THEKULTHILI LAKE , N.W.T.

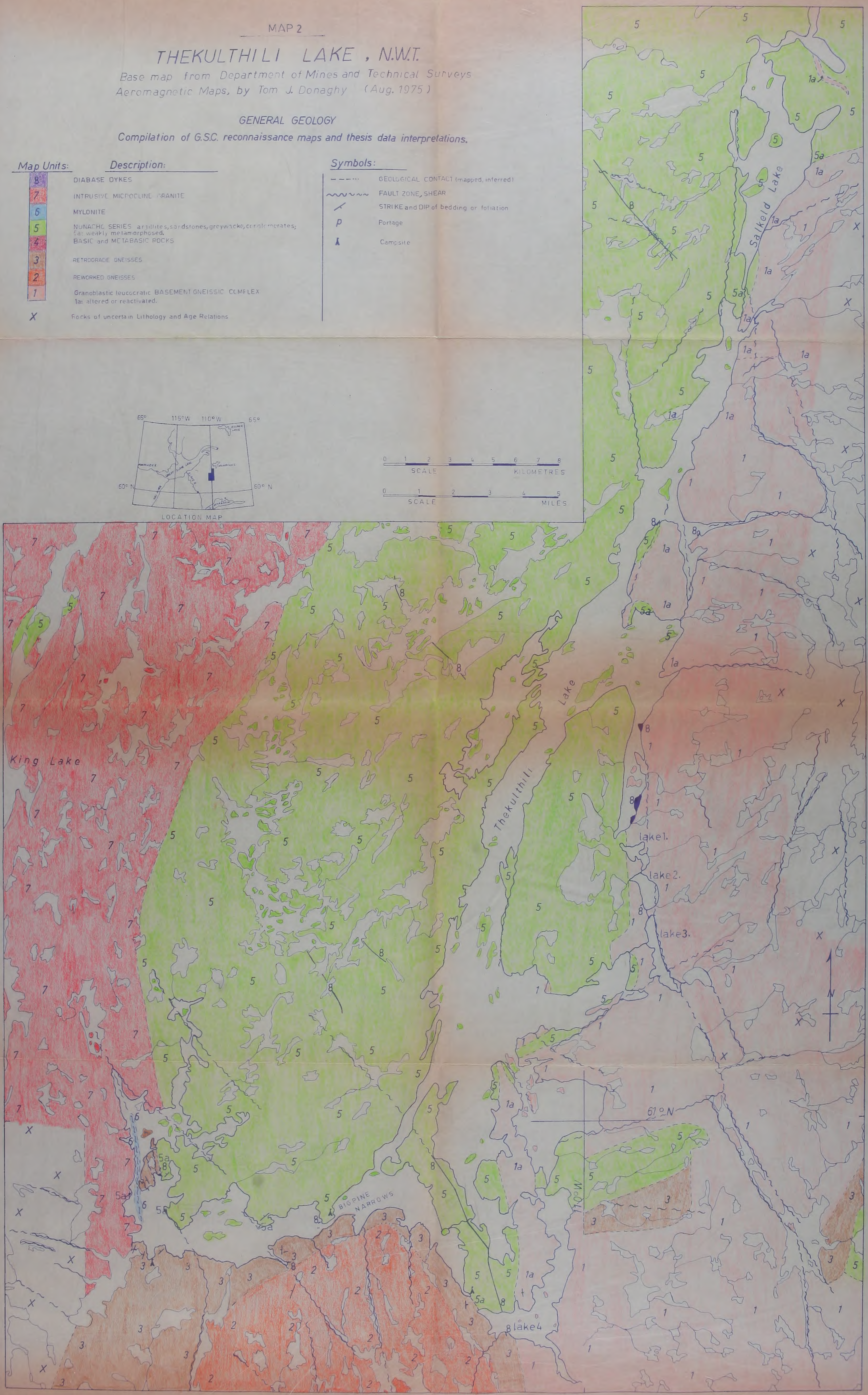
Base map from Department of Mines and Technical Surveys
Aeromagnetic Maps, by Tom J. Donaghy (Aug. 1975)

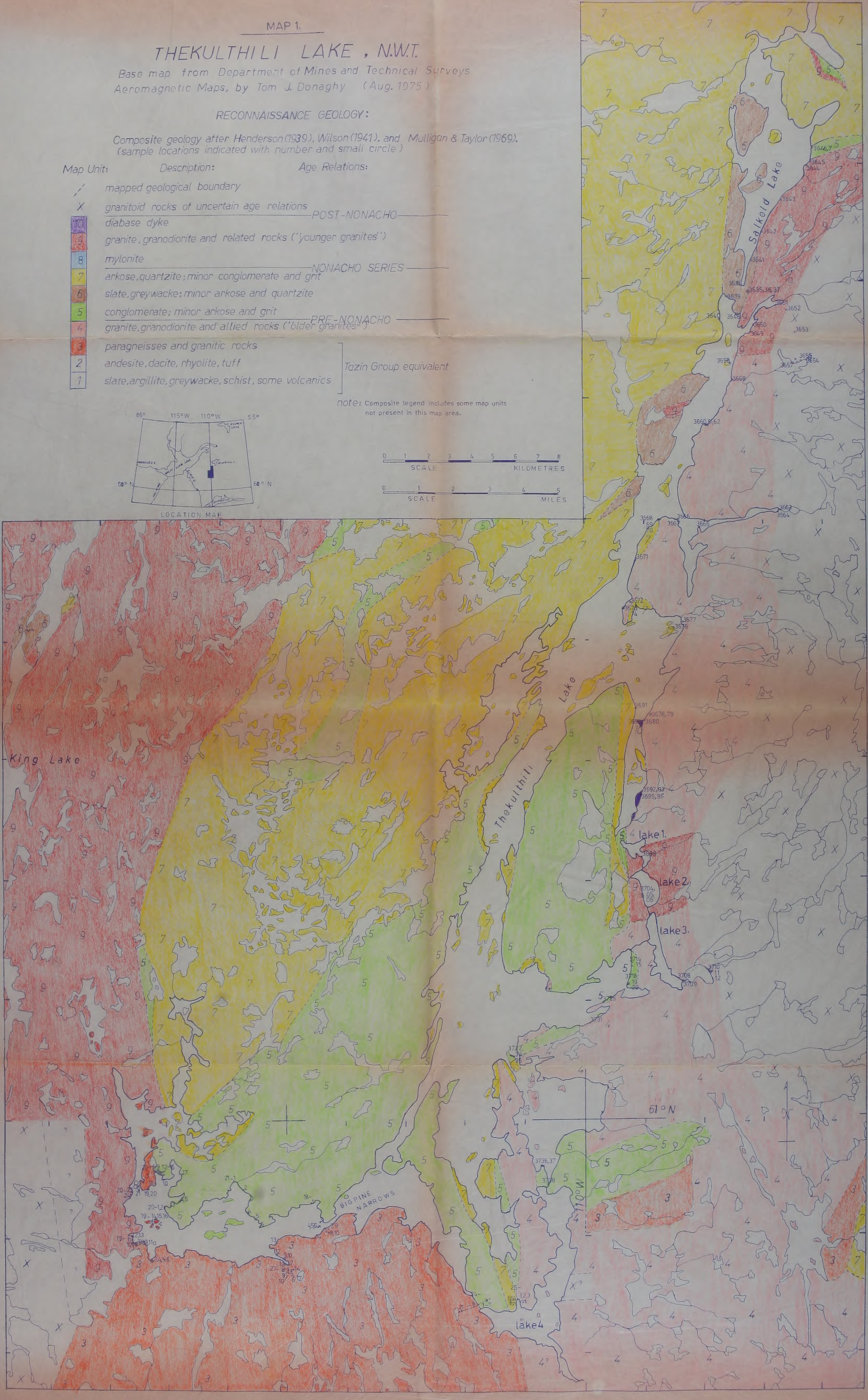
GENERAL GEOLOGY

Compilation of G.S.C. reconnaissance maps and thesis data interpretations.

Map Units:	Description:
8	DIABASE DYKES
7	INTRUSIVE MICROCLINE GRANITE
6	MYLONITE
5	NUNACHO SERIES argillites, sandstones, greywacke, conglomerates; 5a: weakly metamorphosed.
4	BASIC and METABASIC ROCKS
3	RETROGRADE GNEISSES
2	REWORKED GNEISSES
1	Granoblastic leucocratic BASEMENT GNEISSIC COMPLEX 1a: altered or reactivated.
X	Rocks of uncertain Lithology and Age Relations

Symbols:	
- - - ···	GEOLOGICAL CONTACT (mapped, inferred)
~~	FAULT ZONE, SHEAR
⟋	STRIKE and DIP of bedding or foliation
p	Portage
⅄	Campsite





MAP 1.

THEKULTHILI LAKE , N.W.T.

Base map from Department of Mines and Technical Surveys
Aeromagnetic Maps, by Tom J. Donaghy (Aug. 1975)

RECONNAISSANCE GEOLOGY:

Composite geology after Henderson (1939), Wilson (1941), and Mulligan & Taylor (1969).
(sample locations indicated with number and small circle)

Map Unit:	Description:	Age Relations:
⁄	mapped geological boundary	
X	granitoid rocks of uncertain age relations	
		POST-NONACHO
10	diabase dyke	
9	granite, granodiorite and related rocks ('younger granites')	
8	mylonite	
		NONACHO SERIES
7	arkose, quartzite; minor conglomerate and grit	
6	slate, greywacke; minor arkose and quartzite	
5	conglomerate; minor arkose and grit	
		PRE-NONACHO
4	granite, granodiorite and allied rocks ('older granites')	
3	paragneisses and granitic rocks	Tazin Group equivalent
2	andesite, dacite, rhyolite, tuff	
1	slate, argillite, greywacke, schist, some volcanics	

note: Composite legend includes some map units not present in this map area.

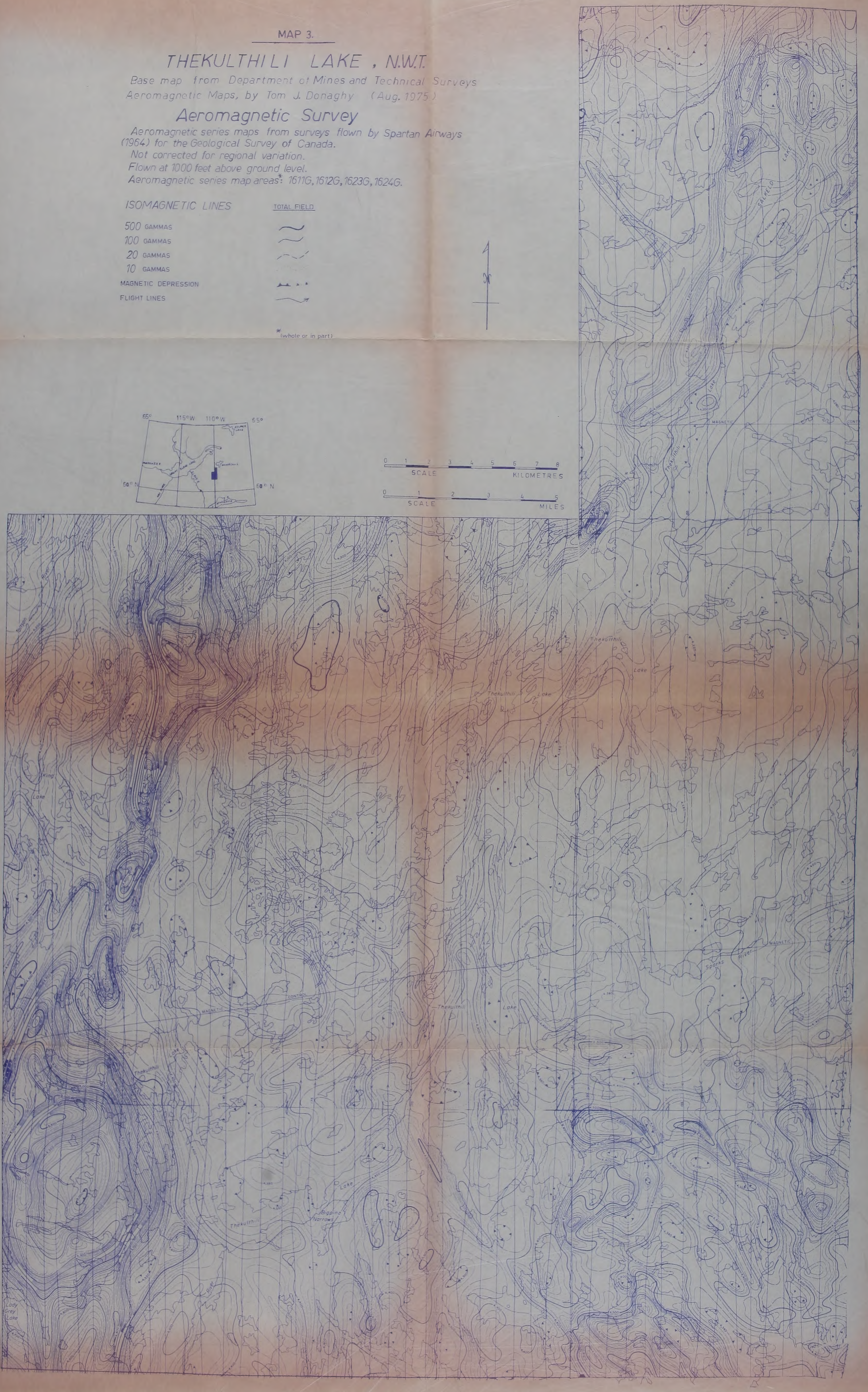
MAP 3.

THEKULTHILI LAKE , N.W.T.

Base map from Department of Mines and Technical Surveys
Aeromagnetic Maps, by Tom J. Donaghy (Aug. 1975)

Aeromagnetic Survey

Aeromagnetic series maps from surveys flown by Spartan Airways (1964) for the Geological Survey of Canada.
Not corrected for regional variation.
Flown at 1000 feet above ground level.
Aeromagnetic series map areas*: 1611G, 1612G, 1623G, 1624G.



*(whole or in part)